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MUSCULOSKELETAL DISORDERS RELATED TO CIGARETTE SMOKING AND TOBACCO USE

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Musculoskeletal disorders commonly occur and result in considerable disability. The identification of a modifiable risk factor for musculoskeletal disorders is of public health importance. This dissertation examined the occurrence of musculoskeletal disorders and their association with cigarette and tobacco use. The first study used a cross-sectional design to assess the relationship of musculoskeletal shoulder disorders with cigarette and tobacco use in 1291 automotive manufacturing workers. Sixteen percent of the workers reported shoulder symptoms in the previous year, while 37% had signs of a shoulder disorder on physical examination. In multivariate logistic regressions controlling for age, gender, workplace ergonomic stressors and other convariates, current and former smokers had odds ratios of 1.46 and 1.20 for symptoms and 1.46 and 1.27 for signs of shoulder disorders, respectively, as compared to never smokers. A statistically significant dose-response was found for pack-year history and the number of cigarettes currently smoked per day on the prevalence of shoulder disorders. The second study prospectively followed 198 senior military officers for ten months to evaluate the incidence of musculoskeletal disorders as (truncated after 200 words)

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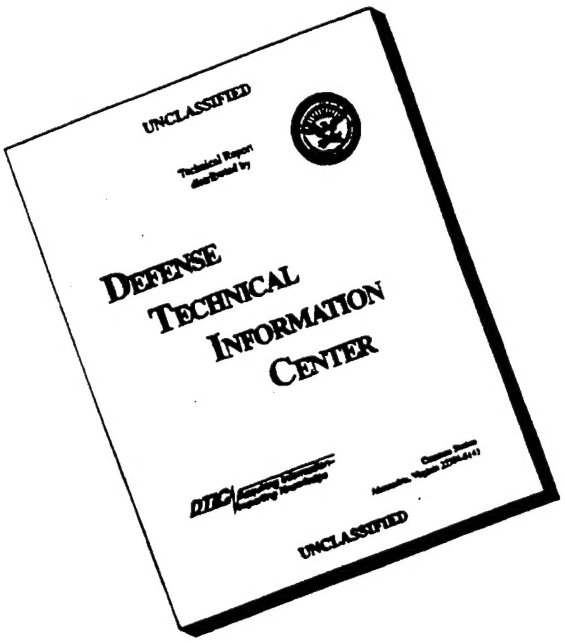

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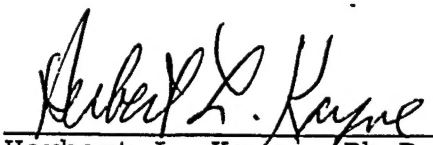

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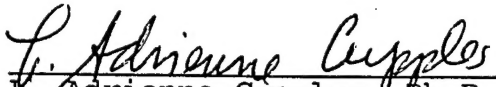

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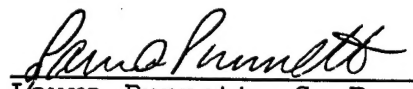

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MUSCULOSKELETAL DISORDERS RELATED TO

CIGARETTE SMOKING AND TOBACCO USE

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ABSTRACT

Musculoskeletal disorders commonly occur and result in considerable disability. The identification of a modifiable risk factor for musculoskeletal disorders is of public health importance. This dissertation examined the occurrence of musculoskeletal disorders and their association with cigarette and tobacco use.

The first study used a cross-sectional design to assess the relationship of musculoskeletal shoulder disorders with cigarette and tobacco use in 1291 automotive manufacturing workers. Sixteen percent of the workers reported shoulder symptoms in the previous year, while 37% had signs of a shoulder disorder on physical examination. In multivariate logistic regressions controlling for age, gender, workplace ergonomic stressors and other covariates, current and former smokers had odds ratios of 1.46 and 1.20 for symptoms and 1.46 and 1.27 for signs of shoulder disorders, respectively, as compared to never smokers. A statistically significant

dose-response was found for pack-year history and the number of cigarettes currently smoked per day on the prevalence of shoulder disorders.

The second study prospectively followed 198 senior military officers for ten months to evaluate the incidence of musculoskeletal disorders as reported in their medical records among current, former and never cigarette and tobacco user. Twenty-eight percent of the subjects had one or more disorders, with 43% of those disorders affecting the lower extremities. Muscle strains, ligament strains, and tendonitis were the most common diagnoses. After adjusting for age, body mass index, maximum oxygen uptake, activity level and drinks per week, current smokers had odds ratios of 2.31 for any body region and 10.70 for lower extremity musculoskeletal disorders compared to never smokers. Former smokers had intermediate values.

The third study examined the effect of cigarette and tobacco use on the frequency of musculoskeletal disorders during the previous 5 years among 178 senior military officers. The annualized rate of musculoskeletal disorders to any body region and to the lower extremities was 27.8 and 11.6 per 100 person-years, respectively. There was no statistically significant association between cigarette and tobacco use and the rate of musculoskeletal disorders; in fact, current smokers had the lowest rates of disorders.

The results of this dissertation suggested a positive association between musculoskeletal disorders and cigarette and tobacco use, that was stronger for lower than for upper extremity disorders. However, further research is needed, especially given the contrary findings of the third study.

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CHAPTER 1

BACKGROUND

Cigarette smoking has been well established as a risk factor for a wide range of diseases in over twenty reports issued by the Surgeon General since 1964 (US DHEW 1964; US DHHS 1989). Smoking has been listed as an important cause of vascular conditions such as coronary heart disease, atherosclerotic peripheral vascular disease and cerebrovascular disease (stroke). Smoking has been cited as the major cause of respiratory conditions such as chronic bronchitis, emphysema, and cancers of the lung and larynx. It is considered a major cause of oral and esophageal cancer, and a contributory factor in bladder, pancreatic and renal cancers. Smoking has been identified as a contributing cause of intrauterine growth retardation and low birthweight babies.

It is postulated that smoking also may contribute to increased incidence of musculoskeletal disorders. Cigarette smoking may reduce musculoskeletal tissue oxygenation and make tissues more sensitive to stress, both to sudden high-load stress causing acute injury and to prolonged or repetitive low-load stress causing chronic trauma. Tissue recovery from acute and chronic injury may also be delayed or incomplete.

This review of literature summarizes previous findings on the physiologic effects of smoking as related to cardiovascular and neuromuscular function. Epidemiologic studies on the relationship between cigarette and tobacco use and various musculoskeletal disorders are examined. Brief allusions are made to these studies in the individual papers that follow.

Physiology of Cigarette Smoking

Cigarette smoke is a combination of combustion gases and suspended particles. More than 4000 known compounds have been identified in tobacco smoke (US DHHS 1989) Carbon monoxide is one of the gases produced by cigarette smoke and is elevated in the alveoli and blood of smokers (Benowitz 1983; Castleden 1974). Carbon monoxide bonds with hemoglobin to form carboxyhemoglobin (COHb). Nonsmokers have between .5% and 1.5% concentration of carboxyhemoglobin in their blood (Nat Research Council 1977). In a study of men aged 34 to 64 years, cigarette smokers had an average of 4.7% COHb (Wald 1981). Habitual heavy smokers are reported to have between 5% and 10% COHb (Benowitz 1990; Benowitz 1983).

Carbon monoxide bonds with hemoglobin at the same point on the hemoglobin molecule as oxygen. It bonds with hemoglobin 210 times more readily than oxygen given the same

alveolar partial pressure (Guyton). Carboxyhemoglobin is also reported to shift the oxygen dissociation curve to the left so that hemoglobin saturation with oxygen is greater for a given partial pressure of oxygen and therefore less oxygen is available to be given up to the tissues (Becker 1990). Some researchers also report that carbon monoxide may bond with important extravascular proteins such as myoglobin (Becker 1990) and affect the cytochrome enzyme system (Benowitz 1983). In these ways cigarette smoking, by increasing carbon monoxide levels in the alveoli and blood, may reduce oxygen delivery to musculoskeletal tissues and reduce oxygen utilization by these tissues.

Hydrogen cyanide, nitrogen oxide, and volatile nitrosamine are additional gases found in cigarette smoke. Blood levels of cyanide and thiocyanate are two to four times greater in smokers than in non-smokers (Benowitz 1983). Cyanide inhibits terminal cytochrome oxidase in the respiratory chain and thus reduces the body tissues' ability to utilize oxygen (Becker 1990).

The particulate phase of cigarette smoke includes nicotine and tar. The nicotine in acidic cigarette smoke is primarily absorbed through the bronchial tree and alveoli (Benowitz 1986). It is rapidly distributed via the blood stream to body tissues. The average amount of nicotine in blood plasma is reported to be between .5 and 4.0 ng/ml in

nonsmokers, and between 15 and 40 ng/ml in cigarette smokers (US DHHS 1988; Jarvis 1984; US DHHS 1989). Plasma blood levels of nicotine are also elevated in cigar, pipe, and smokeless tobacco users.

Nicotine stimulates the sympathetic nervous system and skeletal neuromuscular junctions (Benowitz 1986). Nicotine causes vasoconstriction in the limbs, abdominal organs and heart. Skin temperature of the fingertips and toes is reduced (Rosenberg 1980). Nicotine increases heart rate, blood pressure, myocardial contractility, and myocardial oxygen demand (Benowitz 1990; Rosenberg 1980). Nicotine increases the release of cortisol, vasopressin, growth hormone, adrenocorticotropic hormone (ACTH) and beta-endorphin into the blood stream.

In muscle tissue nicotine causes depolarization at neuromuscular junctions and muscle contractions similar to acetylcholine, but nicotine is not destroyed or is destroyed slowly by cholinesterase (Guyton 1981). The application of moderate amounts of nicotine to muscle fibers is reported to cause continued localized depolarization in muscle fibers with increased ion leakage leading to the development of new action potentials and a state of muscle spasm. The application of extreme amounts of nicotine causes so much of the membrane to depolarize that the muscle fiber can no longer conduct impulses and flaccid paralysis occurs (Guyton

1981).

Studies examining the effects of cigarette smoking on electromyogram (EMG) activity have reported varying results. A 1977 study found cigarette smoking increased EMG activity and tone in the trapezius muscle (Fagerstrom 1977). An earlier study reported a decrease in the amplitude of and EMG response to the patella reflex (Domino 1969). Given the effects of nicotine on the sympathetic nervous system and the neuromuscular junction, the nicotine produced by cigarette smoking may reduce blood flow and oxygen to all musculoskeletal tissues and contribute to muscle/tendon disorders via changes in muscle tone.

Other physiological mechanisms involving cigarette smoking for specific endpoints such as low back pain, hip fractures, and osteoarthritis are discussed below.

Epidemiology of an Association between Musculoskeletal Disorders and Cigarette Smoking

There is some evidence in the epidemiologic literature to suggest a possible association between cigarette smoking and musculoskeletal disorders. Relationships have been reported between smoking and occupational injuries, between smoking and low back pain, and between smoking and some upper and/or lower extremity conditions.

Occupational injuries. Several studies have found that

cigarette smokers have more acute occupational injuries as compared to nonsmokers. Since most occupational injuries are reported to be orthopedic in nature (Hoaglund, 1990), an overall association between smoking and occupational injuries may suggest a similar association between smoking and musculoskeletal disorders in particular. A prospective study of 2537 newly employed postal service workers found that cigarette smokers had an increased risk of occupational injuries (RR=1.40) and of industrial accidents (RR=1.29), and a higher absence rate (34% increase) as compared to nonsmokers (Ryan 1992). Age, gender, race, job classification, drug use and exercise habits were controlled in the analysis. A study of 1500 machinists followed for 10 months reported an injury occurrence of 18% in smokers and 10% in nonsmokers (Naus 1966). The results were stratified by gender only. In both studies the outcome measure of occupational injury included other types of injuries in addition to musculoskeletal disorders. No attempt was made to categorize the injuries by diagnostic groups.

Low back pain. Numerous studies have found a statistically significant positive relationship between the incidence of low back pain and cigarette smoking (Frymoyer 1980, Frymoyer 1983, Biering-Sorensen 1986, Saraste 1987, Deyo 1989, Battie 1989, Heliovaara 1991, Svensson 1993, Boshuizen 1993), while a few studies have found no or an

inconsistent relationship between low back pain and smoking (Riihimaki 1989). The findings of several of these studies are described below.

One of the first studies to report a relationship between smoking and back pain was a cross-sectional study of 1221 men, aged 18 to 55 years who were enrolled in a family practice facility (Frymoyer 1983). Eighty percent of the men with self-reported severe back pain were past or current smokers versus 67% of the men with no history of low back pain. In a multiple comparison analysis that included occupational characteristics, exposure to vehicular vibration, and sports activities, the number of years of cigarette smoking was the single best predictor of low back pain.

Data from the second National Health and Nutrition Examination Survey (NHANES-II) conducted between 1976 and 1980 on 10,404 adults were used to examine the relationship between smoking and back pain (Deyo 1989). The prevalence of back pain increased from 9.6% among nonsmokers to 14.1% among those with over 50 pack-years of smoking, a risk ratio of 1.47 ($p<.00005$). The prevalence of back pain in those whose heaviest cigarette use was more than 3.0 packs per day was 2.6 times the prevalence in nonsmokers. The results were adjusted for age, obesity, chronic cough, exercise level, education, and employment status.

A study of 6673 adults who participated in the Mini-Finland Health Survey found that subjects who smoked at least 20 cigarettes per day had an odds ratio of 1.5 (95% CI 1.1-2.1) for nonspecific low back pain compared to never smokers (Heliovaara 1991). Gender, age, body height, body mass index, prior traumatic back injury, occupational physical and mental stress, work-related driving of motor vehicles, alcohol consumption, and parity were included in the analysis.

Several rationales have been proposed to explain the relationship between smoking and low back pain. Exposure to cigarette smoke may reduce vertebral-body blood flow (Frymoyer 1983). Since the disc depends on the diffusion of nutrients through the vertebral end-plates (Urban 1977), smoking may adversely affect discal metabolism and make the disc more susceptible to injury (Frymoyer 1983). A study of 20 pairs of identical twins who were discordant for smoking history lends some support to this hypothesis. Smokers had 18% greater mean disc degeneration than nonsmokers (Battie 1991). The degeneration effects were similar across all lumbar discs, implicating a causal mechanism that acts systemically.

Another theory suggests that smoking increases coughing, which in turn elevates intradiscal pressures (Nachemson 1971) and may cause increased back pain.

However, several of the studies cited above included chronic coughing as well as cigarette smoking to their multivariate analysis. Coughing alone was insufficient to account for all of the observed back pain in smokers (Frymoyer 1980, Deyo 1989).

Cigarette smoking has been associated with decreased bone density (Slemenda 1989, McMulloch 1991, Slemenda 1992, Hopper 1994) and osteoporosis (Daniell 1976). Osteoporosis may result in microfractures of the trabeculae in the lumbar vertebral bodies and thus cause low back pain (Svensson 1993, Hansson 1981).

Finally, smoking may be a surrogate measure for other behaviors which increase the risk of back pain. Some studies have controlled in varying ways for age, gender, education, occupational physical and mental stress, alcohol use, height, obesity, recreational activity, parity, and some mental health measures, and still found an association between smoking and back pain. However, smoking could still be a marker for other unmeasured behaviors that increase the risk of back pain (Frymoyer 1983, Deyo 1989, Boshuizen 1993).

Upper and lower extremity musculoskeletal disorders. Several studies have found an association between cigarette smoking and musculoskeletal disorders in the upper and/or lower extremities. A cross-sectional study of 4054 Dutch

subjects examined the relationship between smoking and self-reported back pain across 13 occupations (Boshuizen 1993). However, they found that the relationship between smoking and pain in the extremities was stronger and more consistent than the relationship between smoking and pain in the back or neck. In the construction industry, the age-adjusted prevalence difference of **arm pain** between current smokers and never smokers was 10.0% (90% CI 6.1-13.8%), and between ex-smokers and never smokers was 9.1% (90% CI 4.6-13%). The age-adjusted prevalence difference of **leg pain** between current smokers and never smokers was 6.0% (90% CI. 1.2-10.7%), and between ex-smokers and never smokers was 4.9% (90% CI 0.9-8.9%). This study suggested a causal mechanism common to all joints rather than one acting exclusively on the spine.

A cross-sectional study of 207 men, employed in 3 different job categories within the construction industry, examined the effect of loads lifted at work, vibration, and years of manual labor on the prevalence of **shoulder tendinitis** (Stenlund 1993). Although it was not the focus of the study, a significant positive relationship was found between smoking habits and the prevalence of right shoulder tendinitis. Depending on the logistic regression model used, the odds ratios for right shoulder tendinitis comparing former and current smokers to nonsmokers ranged

from 3.06 to 3.37 (95% CIs 1.09-9.43), and for left shoulder tendinitis the odds ratios ranged from 2.03-2.15 (95% CIs .65-6.76). Age, dexterity, participation in sports, and occupational stressors were included in the analysis.

A study of 109 cases who consulted a physician for new **musculoskeletal disorders in the neck and shoulder** and 637 community controls found an odds ratio of 3.7 (90% CI 1.8-7.5) for current smoking, while controlling for age, gender, ethnic background, exercise, having preschool children, and numerous work exposures (Ekberg 1994). The most common diagnosis was tension neck syndrome (47%) followed in frequency by humeral tendinitis (27%).

A few studies examining potential risk factors for **carpal tunnel syndrome** have included data on cigarette smoking habits and have reported conflicting results. A nested case-control study of carpal tunnel syndrome, among 17,032 women taking part in the Oxford (Eng) Family-Planning Association contraceptive study, compared 154 hospital-referred women with carpal tunnel syndrome to controls matched (1:1) for age, clinic and date of recruitment (Vessey 1990). The incidence of carpal tunnel syndrome tripled as smoking increased from 0 to 25 or more cigarettes per day. Age, social class, parity, obesity, interval since last pregnancy, and duration of oral contraceptive use were controlled in the analysis.

Two studies were found which did not reveal a significant relationship between smoking and carpal tunnel syndrome. A case-control study of 40 women admitted to one of 5 Connecticut hospitals for surgical repair of carpal tunnel syndrome and 1043 controls from hospital surgical services, found no association between smoking and carpal tunnel syndrome (Dieck 1985). Cases and controls were matched for gender, age, race, hospital, and admission date. A case-control study of 38 men who had surgery for carpal tunnel syndrome, with 4 controls for each case, examined the relationship between carpal tunnel syndrome and selected occupational stressors (Wieslander 1989). Two of the controls for each case were drawn from the hospital surgical service, while the other 2 controls were drawn from the local population. The four controls were matched to each case for gender, age, and year of operation for the hospital referents. No significant difference was found in the frequency of current smokers between the cases and all of the controls [OR=1.5 (95% CI 0.7-3.5)]. The odds ratio for current smoking between the cases and the population controls was 2.1 (95% CI .7-6.1).

Although the evidence is equivocal, smoking has been implicated as a possible risk factor for **hip fractures** in a number of studies (Wickham 1989; Paganini-Hill 1981, 1991; LaVecchia 1991; Grisso 1991; LaCroix 1991, 1992; Johansson

1992). Several of these studies are briefly described. A hospital-based case-control study of 209 women with hip fractures and 1449 controls admitted for non-traumatic, acute conditions found a significant increase in the risk of hip fractures in former smokers [RR=1.7 (95% CI 1.0-3.0)] and current smokers [RR=1.5 (95% CI 1.0-2.1)] as compared to nonsmokers (LaVecchia 1991). The study noted an increased risk with increased number of cigarettes smoked per day and with increased duration of smoking. Age, area of residence, education, body mass index, menopause status, use of estrogen replacement therapy, and alcohol consumptions were included in the analysis. A 5-year prospective study of 9531 men and women from three cohorts of the National Institute on Aging's Established Populations for Epidemiologic Studies of the Elderly found that current smoking was significantly associated with hip fractures [RR=1.51 (95% CI 1.04-2.19)] after adjusting for age, sex, impaired mobility, body mass index, and alcohol use (LaCroix 1990, LaCroix 1992). A prospective study of 8600 women and 5049 men living in a California retirement community found 418 hip fractures within a 7-year period. Women smokers had a significant increase in the risk of hip fractures [RR=1.8 (95% CI 1.3-2.6)] as compared to nonsmokers. The relative risk in male smokers was 2.2 (95% CI 1.0-4.8) compared with nonsmokers. The risks decreased slightly when adjusted for

age, body mass, active exercise, age at menarche, and number of children.

Some studies have found no significant increase in risk of hip fractures among smokers as compared to nonsmokers (Kreiger 1981, Hemenway 1988, Felson 1988, Holbrook 1988, Farmer 1989). A 4-year prospective study of 96,508 middle aged nurses enrolled in the Nurses' Health Study found 925 cases of either a hip or forearm fracture (Hemenway 1988). No relationship between smoking and risk of fracture was found while adjusting for age. The authors suggested that smoking may not have altered the risk of fractures because the subjects were too young to be affected by smoking induced osteoporosis and noted that the etiology of hip and forearm fractures may differ. A retrospective cohort study of 5209 men and women followed from 1952 to 1988 found 217 cases of hip fractures (Felson, 1988). The number of cigarettes smoked per day was not associated with risk of hip fractures. The odds ratio for hip fracture was 1.04 (95% CI .90-1.20) per 10 cigarettes smoked per day, when adjusted for sex, age, relative body weight, and alcohol consumption.

Several mechanisms have been proposed to explain a possible association between smoking and hip fractures (Cummings 1985, Paginini-Hill 1991). Female smokers have been found to have decreased bone density compared to

nonsmokers (Slemenda 1989, McCullock 1991, Johansson 1992, Hopper 1994) which may be partially related to an effect of smoking on estrogen production and metabolism: women who smoke are reported to be thinner (Williams 1982, Willet 1983) and produce less endogenous estrogen, have lower urinary estrogen levels (MacMahon 1982), undergo menopause earlier than nonsmokers (Jick 1977, Kaufman 1980), have lower circulating levels of estrogen during estrogen replacement therapy (Jensen 1985), and eliminate the protective effect of oral estrogen replacement on risk of hip fracture (Kiel 1992). Male smokers also have been found to have decreased bone density as compared to nonsmokers (Slemenda 1992, Johansson 1992), with no known reduction of estrogen levels (Barrett-Connor 1987). Therefore, smoking appears to have an additional effect on bone mass unrelated to estrogen metabolism. This effect may be mediated by higher cortisol levels in smokers (Friedman 1987).

Surprisingly, several studies have found a negative association between smoking and radiographic evidence of **osteoarthritis** of the knee. A cross-sectional study using data on 5195 adults from the first US National Health and Nutrition Examination Survey of 1971-75 (HANES I) examined the relationship between radiographic osteoarthritis of the knee and various risk factors (Anderson 1988). Smokers had a lower age-adjusted prevalence of osteoarthritis of the

knee than nonsmokers [males OR=0.79 (95% CI 0.62-0.98); females OR=0.74 (95% CI 0.55-0.98)]. When age, race, body mass index, skin thickness, income, education level, marital status and uric acid levels were controlled in the analysis, the protective effect of cigarette smoking became non-significant [males OR=0.79 (95% CI 0.61-1.02); females OR=0.85 (95% CI 0.62-1.59)] but did not change substantially in magnitude. An historical prospective study was conducted on 1415 elderly members of the Framingham Heart Study cohort (Felson 1989). When average cigarette consumption between the years of 1948-1962 was considered, 37% of the non-smokers, 32% of the light smokers, and 25.4% of the heavy smokers developed knee osteoarthritis as of 1985. The odds ratio for knee osteoarthritis among smokers (per 20 cigs/day) was 0.74 (95% CI 0.57-0.95) controlling for age, gender, weight, the square of weight, weight change, knee injury, sports participation, physical activity level, coffee and alcohol consumption.

Several hypotheses have been suggested to explain the modest protection smoking appears to provide against osteoarthritis (Felson 1989). Some constituents of smoking may affect the cartilage directly, perhaps stabilizing progressive osteoarthritic changes. Smoking's osteopenic effect may protect joints by making subchondral bone more deformable to impact loads. It is also possible that

unmeasured or inadequately controlled confounders may be affecting the results.

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CHAPTER 2

MUSCULOSKELETAL DISORDERS RELATED TO CIGARETTE SMOKING AND TOBACCO USE

INTRODUCTION

Musculoskeletal impairments are among the most common of medical conditions. It is reported that at least 15% of patients seen by primary care physicians suffer from either a disorder or injury of the musculoskeletal system (Salter 1983). Workers in industrial settings have noted a prevalence of persistent shoulder pain originating from musculoskeletal tissues of between 11 and 40% (Stenlund 1993, Herberts 1981, Punnett 1985, Lupopajarvi 1979). Among military personnel, annualized rates of musculoskeletal disorders have ranged from 52 per 100 male active duty soldiers to 93 per 100 male infantry soldiers (Tomlinson 1987, Knapik 1993). A study, using data from the US Health and Nutrition Examination Survey (HANES I) of 1971-1975 on 6,913 adults, estimated that 34,741,000 adults in the United States between the ages of 25-74 years (32.6%) have physician-observable musculoskeletal abnormalities; 31,612,000 adults (29.7%) have self-reported musculoskeletal symptoms (Cunningham 1984).

The disability associated with musculoskeletal disorders is significant. A study of military personnel

reported an average loss of active duty days ranging from 2.3 days per overuse injury to 103.2 days per fracture (Knapik 1993). Data from HANES I found that 21% of adults with a history of musculoskeletal symptoms reported moderate to severe activity restriction, 18% reported a change in job status, and 11% reported having lost 5 or more days from work in the past year because of their condition (Cunningham 1984).

Given the high prevalence of musculoskeletal disorders and associated disability, the identification of a contributing cause - especially a modifiable cause - would have important public health implications.

Cigarette smoking has been well established as a risk factor for a wide range of diseases in over twenty reports issued by the Surgeon General since 1964 (US DHEW 1964, US DHHS 1989). Given the impact of cigarette smoking on many body systems, it is postulated that smoking may also contribute to an increased incidence of musculoskeletal disorders. Cigarette smoking may reduce musculoskeletal tissue oxygenation and increase muscle tone, making tissues more sensitive to stress, both to sudden high-load stress causing acute disorders and to prolonged or repetitive low-load stress causing chronic disorders. Tissue recovery from acute and chronic disorders may also be delayed or incomplete.

A relationship between cigarette smoking and increased risk of low back pain has been noted in many studies (Frymoyer 1983, Deyo 1989, Battie 1989, Heliovaara 1991). However, the role of cigarette smoking in the development of musculoskeletal disorders of the extremities has not been well defined.

The purpose of this research project was to explore a potential association between cigarette smoking and other tobacco use and the incidence of musculoskeletal disorders, to quantify the magnitude of risk, and examine a possible dose-response relationship. Specifically, the project 1) used standardized interviews and physical examinations to determine the prevalence of musculoskeletal shoulder disorders among current, former and never cigarette smokers in a sample of about 1300 automotive manufacturing workers; 2) used standardized interviews and prospective medical records to quantify the effect of cigarette smoking on the incidence of musculoskeletal disorders, over a period of one academic year, in a group of 200 senior military officers attending The U.S. Army War College; and 3) used standardized interviews and medical records to quantify the effect of cigarette smoking on the frequency of musculoskeletal disorders during the previous 5 years in the group of 200 senior military officers at The U.S. Army War College.

For this project, musculoskeletal disorders were defined as regional conditions affecting the musculoskeletal system including structures such as muscles, tendons, bursa, ligaments, joint capsules, bone, and cartilage. Musculoskeletal disorders typically result in local pain and tenderness, and, depending on which structures are injured, may also result in pain with resisted isometric muscle contraction, pain with joint motion, and limited joint motion. The types of musculoskeletal disorders noted in this project were influenced by the age, type of work and recreational activities of the subjects, and by the methods used to ascertain the disorders. Study 1 investigated acute and chronic musculoskeletal disorders affecting the shoulder. Studies 2 and 3 investigated acute musculoskeletal disorders occurring throughout the body, of which a large proportion involved the lower extremities. Given the preponderance of lower extremity disorders, these disorders were specifically examined in these two studies.

A number of potential confounding variables have been considered in the design and analyses of these studies. In addition to demographic characteristics such as age, gender, and socioeconomic background; body mass index, work and leisure activities, and alcohol consumption have been included. Numerous studies have associated cigarette smoking with low body mass index, low exercise levels, and

increased alcohol consumption. High or low body mass index has been associated with musculoskeletal overuse and traumatic injuries (Reynolds 1994), carpal tunnel syndrome (Vessey 1990), and low-back pain (Deyo 1989). High or low exercise/activity levels have been related to musculoskeletal injuries (Jones 1993, Pollock 1977) and low-back pain (Frymoyer 1983, Svensson 1983). High alcohol consumption has been associated with serious injuries (DHHS 1990, Room 1987, Sutocky 1993), hip fractures (Grisso 1991), and orthopedic disorders (Kristenson 1986).

STUDY 1: CIGARETTE SMOKING AND THE PREVALENCE OF MUSCULOSKELETAL SHOULDER DISORDERS IN AUTOMOTIVE MANUFACTURING WORKERS

METHODS

Design

The first study of this project was a cross-sectional study that examined the association between cigarette smoking and the prevalence of musculoskeletal shoulder disorders in a group of automotive manufacturing workers. Two outcome variables that identified the presence of a musculoskeletal shoulder disorder were examined: the first case definition was determined from an interviewer-administered questionnaire, while the second case definition was determined from a physical examination.

The study involved the analysis of information collected during the first (baseline) phase of a prospective study "Ergonomic Stressors and Surveillance in Automotive Manufacturing", funded by the United Auto Workers - Chrysler Joint National Committee on Health and Safety. The principal investigator was Dr. Laura Punnett from the University of Massachusetts Lowell. This cross-sectional and prospective study examined the effects of occupational stressors on the incidence of upper extremity disorders and was also concerned with surveillance issues for detecting

work related upper extremity injuries.

Subjects

The sample consisted of 1315 subjects who consented to participate after being recruited from the Large Press, Small Press, and Assembly (Spot Welding) Departments of the Chrysler Warren Stamping Plant and the Machining, Assembly, Maintenance, and Tool Room Departments of the Chrysler Mound Road Engine Plant. Both plants are located near Detroit, Michigan. There was an 85% participation rate within these departments.

Twenty-four of the subjects were excluded from the study for both case definitions because of difficulty completing the questionnaire that was used to obtain information on exposures and the first case definition. In addition to these 24 subjects, 7 subjects were excluded from the study for the second case definition because of difficulty completing the physical examination. Difficulties were due to problems with language (English comprehension, deafness, speech), unreliable responses, or inability to follow physical examination instructions. Thus, a total of 1291 subjects were included for the first set of analyses and 1284 subjects were included for the second.

Data Collection Procedures

After consenting to participate in the study, each

subject was queried by a trained, experienced interviewer to complete a standardized questionnaire (Appendix 1). The questionnaire collected information on demographic background, tobacco use, alcohol consumption, leisure time activities, and previous shoulder injuries. A detailed work history and brief medical history was obtained. If a subject complained of musculoskeletal symptoms of the neck, shoulder/upper arm, elbow/forearm, or wrist/hand that occurred three or more times or lasted more than one week within the year, a module on that body region was completed to obtain more detail on the symptoms, functional limitations and medical care received.

A structured physical examination of the neck and upper extremity (Appendix 2) was performed by a trained, licensed practical nurse. Inspection, specific active and passive ranges of motion, resisted isometric muscle strength testing, and specialized tests (see below) were used to screen for common musculoskeletal disorders involving the shoulder region.

Parts of the questionnaire and physical examination were similar to other questionnaires and physical examinations used to assess musculoskeletal disorders in occupational settings (Silverstein 1984; Punnett 1986; Roach 1991). The physical examination procedures have been described in medical textbooks (Hoppenfeld 1976; Cyriax

1983; Cailliet 1964, 1977; Norkin 1995). Some items in the questionnaire used to measure pain and disability have been examined for reliability (Roach 1991).

Information on smoking status was gathered from the interviewer-administered questionnaire. Cigarette smoking status was categorized as never smoker, current smoker (within the previous 12 months), or former smoker. To explore a possible dose-response, the number of cigarettes smoked per day and cigarette pack-year history were examined. Pack-year history was defined as the number of packs of cigarettes smoked per day multiplied by the number of years of smoking.

A question was also asked on the use of other tobacco products. Answers to this question were combined with the answers to questions on cigarette smoking to categorize tobacco use as never, current or former user.

Information on musculoskeletal disorders affecting the shoulder was gathered from both the questionnaire and the physical examination. Two dichotomous outcome variables were considered in the study, one generated from the questionnaire and the other from the physical examination.

The first dichotomous outcome variable was the presence (yes,no) of a musculoskeletal shoulder disorder, as determined from the questionnaire. One item in the questionnaire asked about the occurrence of symptoms (pain,

cramping, stiffness, aching, soreness, tingling, numbness) during the past year that occurred more than three times or lasted more than one week during the previous year. Subjects with affirmative responses were asked to indicate the affected region on a body diagram and to complete a more thorough questionnaire module on that body region. If responses to the general questionnaire and module indicated that symptoms in the shoulder region occurred more than 12 times or lasted more than 1 week, then the subject was classified as having a musculoskeletal shoulder disorder (first case definition). Subjects who did not meet these criteria were classified as not having a shoulder disorder.

The second dichotomous outcome variable was the presence of a musculoskeletal shoulder disorder as determined by the physical examination. The structured physical examination was performed by a trained licensed practical nurse who was blind to the results of the questionnaire. Each subject was screened for common musculoskeletal disorders by inspection and by performing certain active ranges of motion (ROM). If pain or limitation was found during active ROM, passive ROM was also performed to test specifically for inert joint structures. Pain was graded on a scale of 0 to 10, with 0 equal to no pain and 10 equal to extreme pain. Limitation was graded on a scale of 0 to 3, with 3 equal to normal (90-100% of normal

ROM), 2 equal to slightly limited (67%-89% of normal ROM), 1 equal to moderately limited (34%-66% of normal ROM) and 0 equal to severely limited (0%-33% of normal ROM). Contractile tissues (muscle and tendon) and nerve innervation were evaluated with resisted isometric contractions. Pain and muscle strength were noted. Muscle strength was graded on a scale of 0 to 5, with 5 equal to normal, 4 equal to good, 3 equal to fair, 2 equal to poor, 1 equal to a minimal contraction, and 0 equal to no contraction. Adson's test was performed to screen for thoracic outlet syndrome (Caillet 1966; Hoppenfeld 1976). During this test, pain was recorded using the same grading system as mentioned above.

If the physical examination elicited pain, or ROM less than 90% of normal ROM (limitation scale<=2), or muscle strength less than or equal to 3 (fair) in the shoulder region, then the subject was classified as having a musculoskeletal shoulder disorder (second case definition). Subjects who did not meet these criteria were classified as not having a shoulder disorder.

Information on possible confounding variables was gathered from the interviewer-administered questionnaire. Age was determined from the year of birth. Gender was noted as male or female. Height was recorded in inches and converted to centimeters (inches x 2.54 cm/inch). Weight

was recorded in pounds and converted to kilograms (lbs x .4535 kg/lb). Body mass index was calculated as weight divided by the square of height (kg/m^2). Self-reported information on the number of alcoholic beverages (containing 13-15 g of alcohol) consumed in a typical week was obtained.

Upper extremity exposure to ergonomic stressors was assigned a score of 0 to 28 based on a subject's response to questions on work pace, grip force, whole body effort, upper extremity postures, segmental vibration, whole body vibration, contact stress from tools, and whether or not work was machine-paced. Subjects initially rated their current job on a scale of 0 (low) to 10 (high) for each item. Ratings of 0 were assigned a score of 0, ratings of 1-3 a score of 1, ratings of 4-6 a score of 2, and ratings of 7-10 a score of 3 (Appendix 3). Machine-paced work was rated no=0 or yes=1. The scores for all questions were totaled to create the upper extremity work exposure score. Information was also collected on the number of years worked at Chrysler, in the current plant, and at the current job.

Leisure time activity level was assessed with a question that asked subjects to list leisure time activities and the average number of hours per week they performed the activity. Leisure time activities were coded into low, moderate and high energy expenditure categories for all sports activities, hobbies, and second jobs. The mean

number of kilocalories per kilogram of body weight per hour (Kcal/kg/hr) for each energy expenditure category was estimated by summing the energy expenditure (Ainsworth 1993) for each activity included in a category and dividing by the number of activities in the category. The means for sports activities were: low intensity=4.0 Kcal/kg/hr, moderate intensity=4.7 Kcal/kg/hr, high intensity =6.8 Kcal/kg/hr; for hobbies: very low=2.3 Kcal/kg/hr, moderate=4.7 Kcal/kg/hr; for second jobs: very low/unspecified=2.3 Kcal/kg/hr, moderate intensity=4.7 Kcal/kg/hr (Appendix 4). The total energy expenditure per week in leisure time activities was calculated by multiplying the Kcal/kg/hr for each energy expenditure category by the number of hours per week spent in activities within each category, and then summing for all categories.

If questionnaire responses or physical examination included a history of diabetes, thyroid conditions, lupus erythematosus, gout, cerebral vascular accident (stroke), cancer involving the upper trunk or neck, a ruptured cervical disc, or thoracic outlet syndrome, subjects were classified as having a disease which might place them at higher risk of shoulder symptoms. A self-report history of trauma (laceration, contusion, foreign body, motor vehicle accident, nerve injury, amputation) to the shoulder or upper arm was also obtained.

Data Analysis

Descriptive statistics were compiled on gender, age, height, weight, body mass index, alcohol consumption, exposure to upper extremity ergonomic stressors (work exposure score), leisure time activity level, plant and duration of employment among never-cigarette smokers, current smokers, and former smokers.

Chi-square tests were used to compare the proportions of subjects with musculoskeletal shoulder disorders by smoking status. Crude prevalence odds ratios with 95% confidence intervals were calculated to compare the prevalence of shoulder disorders in current smokers and former smokers, as compared to never smokers.

Subjects were stratified by levels of each potentially confounding categorical variable and by quartiles on each potentially confounding continuous variable. Stratum-specific odds ratios were examined visually and with tests of homogeneity to explore effect modification of the association between smoking and the prevalence of musculoskeletal shoulder disorders. Odds ratios adjusted for each potential confounder were calculated.

The following steps were taken to determine appropriate logistic regression models for the inclusion of multiple potential confounders and cigarette smoking status. Smoking status was represented by two dummy variables for former and

current smokers versus never smokers. Potentially confounding categorical variables such as gender, plant of employment, disease status and trauma status were entered as categorical variables. The potentially confounding variables that were continuous were divided into quartiles. Multiple logistic regression analyses were used to determine stratum-specific prevalence odds ratios for each of these variables while controlling for smoking status. If the natural logarithms of the odds ratios indicated a linear relationship between increasing levels of the potential confounder and the prevalence of shoulder disorders, the potential confounder was entered as a continuous variable in the final logistic regression model.

With smoking status forced into the logistic regression model, the following potential confounders were allowed to step into the model if significant ($p \leq .05$): gender, age, body mass index, disease status, prior trauma to shoulder status, upper extremity work exposure, plant of employment, years of employment at Chrysler, at current plant and at current job, leisure-time activity level, and the number of alcoholic drinks per week. Although several potential confounders (body mass index, leisure-time activity level, alcoholic drinks per week) were not significantly associated with the outcome variables in this study, they were included in the model based on their associations with smoking and

various musculoskeletal disorders in prior studies.

Then first-order interaction terms between smoking status and potential confounders were allowed to step into the model if significant ($p \leq .05$). Interactions between potential confounders and smoking status were also examined using methods suggested by Rothman (1986) and Walker (1981).

To evaluate a possible dose response between the amount of cigarette smoking and the prevalence of musculoskeletal shoulder disorders, the same logistic regression procedures were followed with cigarette pack-year history as a risk factor for shoulder disorders. Prevalence odds ratios for 10-year increment increases in pack-year history were determined with and without adjusting for multiple potential confounders. Current and never cigarette smokers were included in logistic regression analyses that examined the association between the number of cigarettes smoked per day (in 10 cigarette increments) and the prevalence of shoulder disorders.

Similar statistical methods were used to examine the association between cigarette smoking and musculoskeletal shoulder disorders determined by physical examination, as well as the associations between each of the two case definitions and tobacco use.

All analyses were performed using SAS statistical computer software for personal computers (SAS Institute,

Cary, NC). All reported p-values are two sided.

RESULTS

Descriptive characteristics of the subjects are presented in Table 1. Of the 1291 subjects included in the study for the first case definition, 1054 were men and 237 were women, ranging in age from 20 to 73 years (mean=46.6 years). Approximately half of the subjects (n=677) worked at the Warren Stamping Plant, and half of the subjects (n=614) worked at the Mound Road Engine Plant. Subjects had worked at Chrysler for an average of 21.5 years and at their current job for an average of 11.5 years.

Among the 1291 subjects, 408 (31.6%) were never, 255 (19.8%) were former, and 628 (48.6%) were current cigarette smokers. Former smokers had had slightly higher daily cigarette consumption than current smokers (Table 2). When the use of all tobacco products was considered, 353 (27.3%) were never, 262 (20.3%) were former, and 676 (52.4%) were current users.

Two hundred and three (15.7%) of the 1291 subjects reported having shoulder pain or discomfort at least 12 times or lasting more than 1 week during the previous year. The prevalence of shoulder disorders was highest among current cigarette smokers (17.83%), followed by former smokers (15.29%) and never smokers (12.75%) (Table 3).

Current and former smokers had crude prevalence odds ratios of 1.49 (95% CI=1.04-2.12) and 1.24 (95% CI=0.79-1.94) respectively, as compared to never smokers. The chi-square test for linear trend was statistically significant (X^2=4.88, df=1, p=.027). If a causal relationship between smoking and shoulder disorders is assumed, the proportion of shoulder disorders attributed to smoking among current smokers (AR%) is 33% (Hennekens 1987).

Mantel-Haenzel odds ratios for the association between cigarette smoking status and shoulder disorders, adjusted individually for each potential confounder, and the results of the tests of homogeneity for odds ratios are presented in Table 4. Appendix 5 provides odds ratios by smoking status within strata of each potential confounder. Age, gender, disease status, shoulder trauma status, upper extremity work exposure, and plant of employment were significantly associated with shoulder disorders and stepped into the multiple logistic regression model. The prevalence odds ratios for current and former smokers adjusted for these multiple potential confounders was 1.46 (95% CI=1.01-2.10) and 1.19 (95% CI=0.75-1.90) respectively, compared to never smokers (Table 5). A second model, which added body mass index, alcoholic drinks per week, and leisure time activity level to the above multivariate logistic regression model, produced similar results (Tables 3 and 5).

The test of homogeneity of odds ratios across quartiles of drinks per week for former smokers was statistically significant (Table 5). One interaction term, the term for former smokers times alcoholic drinks per week, was significant when added to the multiple logistic regression model. Former smokers who currently drink had an increased risk of musculoskeletal shoulder disorders that was greater than the additive and multiplicative effects of being a former smoker and a drinker (Appendix 6). Neither the addition of pack-year history nor the number of cigarettes smoked per week to this model changed the odds ratio or significance of the interaction term. Applying the multivariate model, former smokers who did not drink had a prevalence odds ratio of 0.94 (95%CI=0.56-1.55) compared to never smokers who did not drink, while controlling for multiple potential confounders (Kleinbaum, p.482-487). Former smokers who consumed 5 drinks per week and 10 drinks per week had prevalence odds ratios of 1.35 (95%CI=0.84-2.16) and 1.95 (95%CI=1.12-3.39) respectively, compared to never smokers who did not drink. There was no additive or multiplicative interaction between current smokers and alcoholic drinks per week.

The effects of using any tobacco products on the prevalence of reported shoulder pain was similar to that of current and former cigarette smokers; current and former

tobacco users had a higher prevalence of shoulder disorders than never smokers (Table 6). The odds ratios for current and former users were 1.48 (95% CI= 1.02-2.14) and 1.16 (95% CI=0.73-1.85) respectively, compared to never smokers. The control of multiple potential confounders resulted in odds ratios for current users of 1.46 (95%CI=0.99-2.16) and for former users of 1.11 (95%CI=0.69-1.81) as compared to never users. All tests of homogeneity were nonsignificant (Table 4 and Appendix 7), as were the interaction terms between potential confounders and former and current tobacco use status in the multivariate logistic regression models.

Of the 1284 subjects included in the study for the second case definition, 474 (36.9%) had signs of musculoskeletal shoulder disorders on physical examination. Four hundred fifty-six (35.5%) subjects had shoulder signs consistent with muscle-tendon disorders, while 101 (7.8%) subjects had signs consistent with joint structure (capsule, ligaments, cartilage or bone) disorders, and 14(1.1%) had signs consistent with nervous system disorders. Some subjects had more than one type of disorder on physical examination.

The two case definitions used in this study focus on different time periods and use different methods of ascertaining shoulder disorders, but may be compared. One hundred and sixty-six of the 203 subjects (81.8%) who

reported having shoulder pain at least 12 times or lasting more than 1 week during the previous year (first case definition) also had signs of a shoulder disorder by physical examination (second case definition). Thirty of the 37 subjects who reported shoulder pain in the previous year but did not have signs on physical examination, reported no current symptoms. Seven subjects (3.4%) who reported current shoulder pain were not found to have signs of a musculoskeletal shoulder disorder by physical examination. Among the 474 subjects who had signs of a shoulder disorder on physical examination, 309 did not report having shoulder pain at least 12 times or lasting more than 1 week during the previous year. However, 17 of these subjects reported having shoulder pain more than 3 but less than 12 times during the previous year.

Current cigarette smokers had the highest prevalence of shoulder disorders (40.6%) as determined by the physical examination followed by former smokers (36.6%) and never smokers (31.4%). Current and former smokers had crude prevalence odds ratios of 1.49 (95% CI=1.14-1.94) and 1.26 (95% CI=0.91-1.75) respectively, as compared to never smokers (Table 7).

Mantel-Haenzel odds ratios for the association between cigarette smoking and shoulder disorders adjusted individually for each potential confounder are found in

Table 8. Tests of homogeneity of odds ratios between levels of potential confounders were nonsignificant, except for plant of employment among former smokers. Former smokers at the stamping and engine plants had odds ratios of 0.79 and 1.80 respectively, compared to never smokers (Appendix 8). A similar pattern was seen for shoulder disorders determined from the questionnaire, although the differences among the plants were not as extreme (0.94 and 1.41 respectively). Former smokers at the stamping plant had a lower pack-year history (mean=17.7) than former smokers at the engine plant (mean=22.5, ANOVA F=2.68, df=1, p=.10). The difference in smoking dose among the two plants did not explain these findings, as the control of pack-year history in a logistic regression model did not substantially change the odds ratios. However, after controlling for age, gender, disease status, shoulder trauma status, upper extremity work exposure, plant of employment, body mass index, alcoholic drinks per week, and leisure time activity level the odds ratios for former versus never smokers were 0.91 at the stamping plant and 1.66 at the engine plant. No interaction terms between potential confounders and smoking status were statistically significant when entered in the multivariate logistic regression model.

The control of age, gender, disease status, shoulder trauma status, upper extremity work exposure, plant of

employment, body mass index, alcoholic drinks per week, and leisure time activity level did not change the prevalence odds ratios for shoulder disorders on physical examination by smoking status from unadjusted values (Table 7).

Crude and multivariate adjusted prevalence odds ratios for types of shoulder disorders by smoking status are found in Table 9. Disorders involving muscle-tendon and joint structures were associated with cigarette smoking, whereas disorders involving the nervous system were not. However, the small number of shoulder disorders involving the nervous system provided little information for assessing the effects of smoking.

Table 10 presents the prevalence and odds ratios for shoulder disorders on physical examination according to tobacco use. As with cigarette smokers, current tobacco users had the highest percentage of subjects with shoulder disorders. Odds ratios for current and former tobacco users were 1.44 (95% CI=1.10-1.89) and 1.03 (95% CI=0.73-1.45) respectively, compared to never tobacco users. Only the test for homogeneity between levels of plant of employment for former tobacco users was significant (Table 8 and Appendix 9). No interaction terms between potential confounders and tobacco use status were significant when entered into the multivariate logistic regression model. Odds ratios adjusted for multiple potential confounders were

not appreciably different from the unadjusted odds ratios.

Table 11 presents the prevalence, crude and multivariate adjusted odds ratios for types of shoulder disorders by tobacco use. Similar to the analyses of types of disorders by cigarette smoking, there was a statistically significant association between muscle-tendon and joint disorders with tobacco use.

For both case definitions there was a statistically significant positive association between cigarette pack-year history and prevalence of musculoskeletal shoulder disorders (Table 12). As pack-year history increased by 10-year increments, the odds ratio for shoulder disorder determined by questionnaire increased by 9% (OR=1.09, 95% CI=1.02=1.17) while the odds ratio for shoulder disorder by physical examination increased by 6% (OR=1.06, 95% CI=1.00=1.12). The multivariate adjusted odds ratios were similar to the crude odds ratios. There were no consistent differences in the association between pack-year history and shoulder disorders for current smokers as compared to former smokers.

A positive association was found between the number of cigarettes smoked per day and shoulder disorders among current smokers and never smokers combined (Table 13). The odds ratio for shoulder disorders determined by questionnaire increased 16% (OR=1.16, 95% CI=1.02-1.31) for

each increase in 10 cigarettes smoked per day. The odds ratio for shoulder disorders determined by physical examination increased 8% (OR=1.08, 95% CI=0.98-1.20) for each increase in 10 cigarettes smoked per day. The odds ratios were slightly higher when adjusted for multiple potential confounders .

DISCUSSION

Musculoskeletal shoulder disorders were common among the automotive manufacturing workers in this study. The prevalence of persistent, reported shoulder pain occurring at least 12 times or lasting more than 1 week during the previous year was 15.7%. The prevalence of shoulder symptoms noted during the physical examination was about twice as high (36.9%). The physical examination appeared to include recently or less frequently occurring shoulder disorders in addition to the more persistent disorders noted by the questionnaire. However, it is also possible that some subjects were acclimated to an underlying level of shoulder discomfort and did not report shoulder pain until the procedures used in the physical examination intensified the symptoms.

Although comparisons with previous studies are difficult due to varying criteria for reported shoulder pain and physical examination findings and the intensity of

ergonomic stress to subjects' shoulders, these results seem to fall within the range reported in the literature. Stenlund and associates (1993) found signs of shoulder tendinitis on physical examination for 11.1-14.5% of male bricklayers, 32.7-40.0% of rock blasters and 8.2-17.1% of construction foremen. A 1981 study of male shipyard welders (Herberts 1981) reported a 27% prevalence of repetitive shoulder pain reported by questionnaire and an 18% prevalence of supraspinatus tendinitis on physical examination. Punnett et al (1985), in a study of female garment workers, noted a 19.6% prevalence of persistent shoulder pain reported to last for most days for at least one month during the previous year. Luopajarvi and associates (1979) found an 11.8% prevalence of shoulder disorders by physical examination among female assembly-line packers in food production.

This study did not attempt to determine an exact, medical diagnosis for each subject during the physical examination. However, active and passive range of motion, resisted isometric contractions, and special tests were used to categorize shoulder disorders by the involved structures: muscle-tendon, joint structures (capsule, ligament, articular surface), and nervous system (Cyriax 1983; Waris 1979). The categories were not mutually exclusive. The majority of shoulder disorders were consistent with lesions

to muscles and tendons (96.2% of all cases), followed in frequency by lesions to joint structures (21.3%), and the nervous system (3.0%). Previous studies have also reported muscular pain (Hagberg 1984, Bjelle 1981, Onishi 1976) and tendonitis (Luopajarvi 1979, Waris 1979, Herberts 1981) to be the most common shoulder disorders.

A statistically significant positive association was found between musculoskeletal shoulder disorders and cigarette smoking. Current smokers had 1.5 times and former smokers had 1.2-1.3 times the prevalence odds of having a shoulder disorder as compared to never smokers, after controlling for potential confounders. This relationship was consistent regardless of whether shoulder disorders were reported by questionnaire or identified during a physical examination. The adjusted odds ratios for shoulder disorders for current users of any type of tobacco product compared to never users were similar, while the adjusted odds ratios for former tobacco users compared to never users were weaker, than the adjusted odds ratios comparing current and former cigarette smoker to never smokers. The strongest associations with cigarette smoking and tobacco use were found within the subsets of muscle-tendon disorders and joint structure disorders. No association was noted between cigarette and tobacco use and nerve disorders affecting the shoulder region.

Other factors were also associated with musculoskeletal shoulder disorders. The prevalence of shoulder disorders significantly increased with age, upper extremity work exposure, being female, having a history of trauma to the shoulder or upper arm, and having a history of diabetes, a thyroid condition, lupus erythematosus, gout, stroke, cancer involving the upper trunk or neck, a ruptured cervical disc or thoracic outlet syndrome. The effect of currently smoking on the prevalence of shoulder disorders was similar in magnitude to adding 20 years to one's age or increasing upper extremity work exposure by 6.4 (23%) on a scale of 0 to 28).

The association between former smokers and shoulder disorders as defined by questionnaire was modified by alcohol consumption. Former smokers who currently drink had an increased risk of shoulder disorders that was greater than the additive and multiplicative effects of being a former smoker and drinker. Former smokers who consumed 5 or 10 drinks per week would have a prevalence odds ratios of 1.35 and 2.16, respectively. The cause of this effect modification is unknown and not explained by a difference in levels of smoking. The biological plausibility seems low, since if there is a true interaction between smoking and alcohol affecting the risk of musculoskeletal shoulder disorders, a similar effect modification between current

smokers and alcohol consumption would be expected. There was no additive or multiplicative interaction between current smokers and alcoholic drinks per week.

The results of this study also support a dose-response relationship between the amount of cigarette smoking and musculoskeletal shoulder disorders. Statistically significant positive associations were found between cigarette pack-year history for both current and former smokers and shoulder disorders, adjusting for potential confounders. The prevalence odds for a shoulder disorder increased by 0.06-0.09 for every ten-year increase in pack-year history. A significant positive association was also noted between the number of cigarettes smoked per day by current smokers and the prevalence of shoulder disorders. Current smokers increased their odds of having a shoulder disorder by 0.10-0.20 for every ten cigarettes that they routinely smoked per day.

There are several limitations to the study. In general, subjects were middle-aged men and women with an average of 22 years of work experience at the Chrysler Corporation. To remain employed for this length of time, subjects had had to adapt to and tolerate the physical demands of their jobs. Subjects who were potentially more sensitive to the negative interaction between these ergonomic stressors and the effects of cigarette or tobacco

use may have previously retired from automotive manufacturing, changing to a more sedentary type of job. This selection bias, commonly referred to as a "healthy worker effect" (Rothman 1986), may have lead to an underestimation of the effect of cigarette and tobacco use on the prevalence of shoulder disorders. In fact, current smokers within the youngest quartile, when compared to similarly aged never smokers, had the highest associations between smoking and shoulder disorders (ORs=2.59-2.67) of all age groups (Appendices 5,7-9).

All subjects were employed in automotive manufacturing and performed manual labor. Although upper extremity work exposure to ergonomic stressors was adjusted for in the analyses, subjects' baseline level of upper extremity activity was high, with a mean score of 11.7 on a upper extremity work exposure scale of 0 to 28. The associations between cigarette smoking and tobacco use and musculoskeletal shoulder disorders found in this study may be dependent on an minimal level of physical stress to the shoulder. Results may be different in less active populations who do not routinely use their shoulders in physical activities.

Differential misclassification of exposure and disease status is always possible but unlikely to account for the results of this study. Cigarette and other tobacco use was

determined from an interviewer-administered questionnaire. Self-reported information on smoking habits has been shown to be internally consistent, reproducible, and accurate (Petitti 1981, Pojer 1984). Although the interviewer-administered questionnaire was also the source of information for the first case definition of musculoskeletal shoulder disorders, the interviewer asked about smoking habits prior to shoulder symptoms. There was no reason to believe that subjects would systematically report differing shoulder symptoms based on their smoking and tobacco habits. While the interviewer may have been aware of the study hypothesis, it is doubtful that the subjects were aware of the focus of this study given the wide range of topics included in the questionnaire. The nurse who conducted the physical examination - which was used for the second case definition of shoulder disorders - was blind to the results of the questionnaire. The associations between smoking and tobacco use and shoulder disorders were similar regardless of whether shoulder symptoms were determined from the questionnaire or physical examination, thus supporting the lack of differential misclassification in the data collection process. If misclassification occurred it was most likely random and would have biased the results toward the null.

The inclusion of subjects from one fairly selective

occupational group reduced the possible confounding effects of socioeconomic status, educational background, and access to medical care. Many variables believed to be associated with cigarette smoking or musculoskeletal shoulder disorders such as age, gender, work exposure, leisure-time activity level, alcohol consumption, body mass index, prior trauma to the shoulder region, and diseases such as diabetes, thyroid conditions, lupus erythematosus, gout, stroke, cancer, ruptured cervical disc and thoracic outlet syndrome were included in the study. Some misclassification of confounders may have occurred, but it is doubtful that smoking and tobacco habits differentially affected the quality of information on the confounders. Random misclassification of confounders, if present, would have resulted in residual confounding and contributed to the association between smoking and tobacco use with shoulder disorders. However, given the small amount of confounding noted in the study, it is unlikely that residual confounding would have accounted for the risk estimates.

Only two previous studies were found that examined the relationship between cigarette smoking and shoulder disorders. Stenlund and associates (1993) in a study of 54 male bricklayers, 55 rockblasters and 98 construction foremen found a significant association between smoking status and signs of shoulder tendonitis on physical

examination. The odds ratios varied from 2.0 to 3.4 for former and current smokers compared to never smokers, depending on the multiple regression model considered. A study of 575, 55-year-old residents of Malmo, Sweden found that men with shoulder pain of more than 24-hour duration during the previous month were more likely to be smokers ($p<.05$) (Bergenudd 1994). No odds ratios were provided.

More generally, a cross-sectional study of 4054 Dutch subjects found an association between smoking and regular pain/stiffness in the upper extremities (Boshuizen 1993). In the construction industry, the age-adjusted risk ratio for arm pain/stiffness among current and former smokers compared to never smokers was 1.38 and 1.43 respectively. These results were similar in magnitude to the findings of our study. A study by Ekberg and associates (1994) of 109 cases of musculoskeletal disorders in the neck and shoulder and 637 controls found an odds ratio of 3.7 for current smoking, after controling for age, gender, ethnic background, exercise, having preschool children, and numerous work exposures. Tension neck syndrome was the most common diagnosis (47%) followed in frequency by humeral tendinitis (27%).

Etiological mechanisms for the association between cigarette and tobacco use and musculoskeletal shoulder disorders can be postulated. Cigarette smokers have been

shown to have elevated alveolar and blood levels of carbon monoxide (Benowitz 1983, Castleden 1974). Carbon monoxide preferentially bonds with hemoglobin in place of oxygen to form carboxyhemoglobin, thus reducing the amount of oxygen carried by the blood (Guyton 1981). Carboxyhemoglobin also shifts the oxygen dissociation curve so oxygen is less available to body tissues. Carbon monoxide is also reported to bond with extravascular proteins such as myoglobin (Becker 1990) and affect the cytochrome enzyme system (Benowitz 1983). Hydrogen cyanide, another gas produced by cigarette smoking, and elevated in the blood of smokers (Benowitz 1983), inhibits terminal cytochrome oxidase in the respiratory chain and thus reduces the body tissues' ability to utilize oxygen (Becker 1990).

Nicotine is elevated in the blood of cigarette, cigar, pipe and smokeless tobacco users (US DHHA 1988, Jarvis 1984, US DHHS 1989). It stimulates the sympathetic nervous system causing vasoconstriction in the limbs, abdominal organs and heart (Benowitz 1990, Rosenberg 1980). Nicotine also causes depolarization at neuromuscular junctions and subsequent muscle contractions in a manner similar to acetylcholine, but nicotine is not destroyed or is destroyed slowly by cholinesterase (Guyton 1981). Moderate amounts of nicotine applied to muscle fibers are reported to cause a state of muscle spasm.

These effects of cigarette smoking and other tobacco use to reduce the ability of the blood to carry oxygen, to decrease the utilization of oxygen in cellular metabolism, to constrict blood flow, and to increase muscle tone and spasm may result in cigarette smokers and tobacco users having a greater risk of musculoskeletal disorders. Muscle ischemia, muscle hypoxia, and energy metabolic disturbances have all been proposed as causes of muscular pain (Hagberg 1984, Awad 1973, Henriksson 1988, Jarvholm 1988).

The shoulder region may be particularly susceptible to the effects of smoking and tobacco use. Muscular pain and tendinitis are among the most common causes of shoulder disorders. The supraspinatus tendon, biceps brachii tendon and the upper part of the infraspinatus tendons have been shown to have zones of avascularity, where degenerative changes and microruptures predominantly occur (Rathburn and Macnab 1970). It has been suggested that reduced nutrition and circulation to these tendons are important factors in their degeneration (Hagberg 1984, Waris 1979). Cigarette smoking and tobacco use may worsen circulatory impairment, thus exacerbating the degenerative process in these tendons.

In conclusion, the results of this study demonstrated a small but significant positive association between current cigarette and tobacco use and the prevalence of musculoskeletal shoulder disorders among automotive

manufacturing workers. Former users had a weaker association with increased prevalence of shoulder disorders. A dose-response effect was found for cigarette pack-year history and the number of cigarettes currently smoked per day with the prevalence of shoulder disorders.

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Table 1- Characteristics of 1291 Subjects According to Cigarette Smoking Status. Warren Stamping and Mound Road Engine Plants 1992-93

Characteristics	All Subjects n=1291	Never Smokers n=408	Former Smokers n=255	Current Smokers n=628	P-Value[b]
	mean ± SD[a]	mean ± SD	mean ± SD	mean ± SD	
Age (yrs)	46.6 ± 8.3	45.9 ± 8.8	48.8 ± 7.5	46.1 ± 8.1	.0001
Height (cm)	174.5 ± 9.2	173.8 ± 9.7	174.7 ± 8.1	175.0 ± 9.1	.106
Weight(kg)	83.7 ± 16.2	86.0 ±17.5	86.7 ±15.6	80.9 ±15.0	.0001
Body Mass Index (kg/m²)	27.4 ± 4.9	28.5 ± 5.4	28.4 ± 4.5	26.4 ± 4.4	.0001
UE Work Exposure	11.7 ± 6.0	11.7 ± 6.1	11.3 ± 6.1	11.9 ± 5.9	.325
Years at Chrysler	21.5 ± 6.5	21.0± 6.8	23.0± 5.8	21.3 ± 6.4	.0001
Years at Current Plant	16.8 ± 8.1	16.3 ± 8.0	18.3 ± 8.0	16.6 ± 8.2	.004
Years at Current Job	11.5 ± 8.4	11.9± 8.6	12.2± 8.7	10.9 ± 8.2	.067
	n(%)[c]	n(%)	n(%)	n(%)	
Gender					.042
male	1054(81.6)	322 (78.9)	221 (86.7)	511 (81.4)	
female	237(18.4)	86 (21.1)	34 (13.3)	117 (18.6)	
Plant					.001
Warren	677 (52.4)	243(59.6)	115 (45.1)	319 (50.8)	
Mound Rd	614 (47.6)	165 (40.4)	140 (54.9)	309 (49.2)	
Disease					.588
Yes	192 (14.9)	57 (14.0)	43 (16.9)	92 (14.7)	
No	1098(85.1)	350(86.0)	212 (83.1)	536(85.4)	
Prior Trauma					.468
Yes	19 (1.5)	5 (1.2)	3 (1.2)	11(1.8)	
No	1272(98.5)	408 (98.8)	252 (98.8)	617(98.3)	
Drinks/week					.0001
Range	0-60	0-30	0-50	0-60	
10-90%	0-10	0-7	0-10	0-12	
Median	0.5	0	0.5	1.0	
Mean ± SD	3.5 ± 6.8	2.2 ± 4.4	3.1 ± 6.6	4.5 ± 7.9	

Table 1- Continued

Characteristics	All Subjects n=1291	Never Smokers n=408	Former Smokers n=255	Current Smokers n=628	P-Value [b]
Leisure Activity					.194
Range	0-235	0-209	0-192.9	0-235	
10-90%	0-72.4	0-67.4	0-69.6	0-78.2	
Median	12.0	13.9	8.0	13.6	
Mean ± SD	26.2 ± 36.0	25.8 ± 34.3	24.3 ± 37.8	27.2 ± 36.3.	

[a] SD = standard deviation

[b] Continuous variables tested by analysis of variance, categorical variables tested by chi-square procedures, drinks per week and leisure activity tested by Kruskal-Wallis tests.

[c] Number and columnar percentiles

Table 2- Characteristics of Current and Former Cigarette Smokers Warren Stamping and Mound Road Engine Plants 1992-93

Characteristics	Former Smokers n=255	Current Smokers n=628
Pack-Year History		
range	0-160	0-120
10-90%	2-50	3-45
median	12.5	20
mean ± SD	20.3 ± 22.8	23.0 ± 19.4
No. Cigarettes per day		
range	.5-80	0-60
10-90%	5-40	4-30
median	20	20
mean ± SD	22.5 ± 16.1	18.7 ± 11.4
Years of smoking		
range	0-50	0-60
10-90%	5-30	10-38
median	15	20
mean ± SD	16.1 ± 9.3	23.1 ± 10.5
Years Since Quit		
range	0-40	
10-90%	3-20	
median	10	
mean ± SD	11.9 ± 7.3	

Table 3- Prevalance, Crude and Multiple Risk-Factor Adjusted Odds Ratios for Shoulder Disorders Determined by Questionnaire According to Cigarette Smoking Status

	Never Smoker n=408	Former Smoker n=255	Current Smoker n=628
Number of Cases (%)	52 (12.75)	39 (15.29)	112 (17.83)
Crude OR (95% CI) [a]	1.0	1.24 (0.79-1.94)	1.49 (1.04-2.12)
Adjusted OR (95% CI) [b]	1.0	1.20 (0.75-1.91)	1.46 (1.01-2.13)

[a] Pearson Chi-square = 4.88, p= .087, degrees of freedom = 2;
Chi-square for linear trend = 4.88, p = .027, degree of freedom = 1.

[b] Variables included in the model are age, gender, upper extremity work exposure score, disease (yes/no), prior shoulder trauma, (yes/no), plant of employment, body mass index, alcoholic drinks per week, leisure-time activity level.
Maximum likelihood ratio chi-square = 4.07, p = ≥ .10, degrees of freedom = 2.

Table 4 - Pooled Odds Ratios of Shoulder Disorder Determined by Questionnaire According to Tobacco use (Cigarettes Only and All Forms), Adjusted for Potential Confounders.

Adjusted for	Former	Homogeneity P Value	Current	Homogeneity P Value
A. OR's for Shoulder Disorder According to Smoking Status				
Crude	1.24		1.49	
Gender	1.32	.499	1.53	.693
Age	1.15	.071	1.47	.109
Body Mass Index	1.24	.554	1.58	.589
Disease	1.20	.354	1.48	.366
Prior Trauma	1.24	.555	1.48	.617
Plant of Employment	1.18	.393	1.47	.702
UE Work Exposure	1.27	.542	1.48	.744
Drinks per Week	1.20	.034	1.51	.517
Leisure Activity	1.25	.401	1.50	.763
Years at Chrysler	1.25	.787	1.49	.744
Years at Job	1.24	.969	1.50	.997
B. OR's for Shoulder Disorder According to Tobacco Use Status				
Crude	1.16		1.48	
Gender	1.28	.466	1.57	.574
Age	1.03	.139	1.45	.111
Body Mass Index	1.17	.732	1.55	.667
Disease	1.13	.307	1.48	.298
Prior Trauma	1.16	.728	1.47	.343
Plant of Employment	1.12	.198	1.47	.629
UE Work Exposure	1.19	.712	1.48	.593
Drinks per Week	1.14	.170	1.52	.949
Leisure Activity	1.16	.119	1.48	.741
Years at Chrysler	1.17	.658	1.48	.895
Years at Job	1.17	.820	1.50	.902

Referents were never cigarette smokers

Table 5-Predictions of Shoulder Disorder Determined by Questionnaire According to Cigarette Smoking Status

	Model I			Model II			Model III		
Predictors	Coefficient	P Value [a]	OR	Coefficient	P Value	OR	Coefficient	P Value	OR
Intercept	-4.077	.0001		-4.646	.0001		-4.674	.0001	
Former Smoker	0.176	.456	1.19	0.182	.443	1.20	-0.067	.797	0.94
Current Smoker	0.378	.042	1.46	0.379	.048	1.46	0.419	.029	1.52
Gender (f)	0.545	.004	1.73	0.558	.004	1.75	0.549	.004	1.73
Age	0.020	.048	1.02	0.021	.045	1.02	0.021	.036	1.02
UE Work Exposure	0.067	.0001	1.07	0.066	.0001	1.07	0.066	.0001	1.07
Plant Engine	0.329	.045	1.37	0.309	.064	1.36	0.315	.059	1.37
Disease [b] (yes)	0.467	.020	1.60	0.427	.037	1.53	0.432	.035	1.54
Trauma [c] (yes)	1.425	.005	4.16	1.391	.006	4.02	1.473	.004	4.36
Body Mass Index				0.197	.230	1.02	0.020	.229	1.02
Drinks per Week				0.008	.486	1.01	0.009	.498	0.99
Leisure Activity				-0.0002	.944	1.00	-0.000	.983	1.00
Former * Drinks							0.073	.004	1.08

[a] Maximum likelihood ratio chi-square tests.

[b] Disease includes history of : diabetes, thyroid conditions, lupus erythematosus, gout, stroke, cancer of upper trunk or neck, ruptured cervical disc, or thoracic outlet syndrome.

[c] History of trauma to either shoulder or upper arm.

[d] Interaction term for categories of former and never smokers multiplied by the number of drinks per week.

Table 6 - Prevalence, Crude and Multiple Risk-Factor Adjusted Odds Ratio for Shoulder Disorder by Questionnaire According to Tobacco Use Status

	Never Users n=353	Former Users n=262	Current Users n=676
Number of Cases (%)	45 (12.75)	38 (14.50)	120 (17.75)
Crude OR (95 % CI) [a]	1.0	1.16 (0.73-1.85)	1.48 (1.02-2.14)
Adjusted OR (95%CI) [b]	1.0	1.11 (0.69-1.81)	1.46 (0.99-2.16)

[a] Pearson, Chi-square = 4.75, p = .093, degrees of freedom = 2;
Chi-square for linear trend = 4.66, p = .031, degree of freedom = 1

[b] Variables included in the model are age, gender, upper extremity work exposure score, disease (yes/no), prior shoulder trauma (yes/no), plant of employment, body mass index, alcoholic drinks per week, leisure-time activity level. Maximum likelihood ratio chi-square = 4.36, $p \geq .10$, degrees of freedom = 2.

Table 7 - Prevalence , Crude and Multiple Risk-Factor Adjusted Odds Ratios for Shoulder Disorder Determined by Physical Examination According to Cigarette Smoking Status.

	Never Smoker n = 404	Former Smoker n = 254	Current Smoker n =626
Number of cases (%)	127 (31.44)	93 (36.61)	254 (40.58)
Crude OR (95%CI) [a]	1.0	1.26 (0.91-1.75)	1.49 (1.14-1.94)
Adjusted OR (95%CI) [b]	1.0	1.27 (0.90-1.79)	1.46 (1.10-1.94)

[a] Pearson chi-square = 8.82, p = .012, degrees of freedom = 2;
Chi-square for linear trend = 8.78, p =.003, degrees of freedom = 1.

[b] Maximum likelihood ratio chi-square = 6.987, p = ≤. 05, degrees of freedom = 2.
Variables included in model are age, gender, upper extremity work exposure score, disease (yes/no), prior shoulder trauma (yes/no), plant employment, body mass index, alcoholic drinks per week, leisure time activity level.

Table 8 - Pooled Odds Ratios of Shoulder Disorder by Physical Examination According to Tobacco use (Cigarette Only and All Forms), Adjusted for Potential Confounders.

Adjusted for	Former	Homogeneity P Value	Current	Homogeneity P-Value
A. OR's for Shoulder Disorder According to Smoking Status				
Crude	1.26		1.49	
Gender	1.38	.581	1.54	.328
Age	1.19	.312	1.49	.074
Body Mass Index	1.27	.409	1.57	.977
Disease	1.23	.379	1.48	.101
Shoulder Trauma	1.26	.397	1.47	.990
Plant of Employment	1.21	.018	1.48	.431
UE Work Exposure	1.29	.761	1.46	.889
Drinks per Week	1.27	.275	1.50	.347
Leisure Activity	1.25	.675	1.48	.393
Years at Chrysler	1.21	.543	1.50	.781
Years at Job	1.25	.563	1.49	.874
B. OR's for Shoulder Disorder According to Tobacco Use Status				
Crude	1.03		1.44	
Gender.	1.16	.751	1.55	.275
Age	0.95	.261	1.42	.066
Body Mass Index	1.02	.284	1.50	.985
Disease	1.00	.308	1.44	.100
Shoulder Trauma	1.02	.276	1.42	.693
Plant of Employment	1.00	.013	1.42	.111
UE Work Exposure	1.04	.591	1.42	.964
Drinks per Week	1.05	.262	1.46	.428
Leisure Activity	1.03	.669	1.43	.809
Years at Chrysler	0.97	.729	1.46	.789
Years at Job	1.02	.722	1.44	.722

Table 9 - Prevalence, Crude and Multiple Risk-Factor Adjusted Odds Ratios for Types of Shoulder Disorders as Determined by Physical Examination, According to Cigarette Smoking Status

	Never Smokers n = 404	Former Smokers n = 254	Current Smokers n =626	X^2 (p-value)[a]
Muscle-Tendon Disorder n(%)	122 (30.20)	92 (36.36)	242 (38.84)	
Crude OR (95%CI)	1.0	1.32 (0.95-1.84)	1.47 (1.13-1.92)	8.06 (.018)
Adjusted OR (95%CI)[b]	1.0	1.34 (0.94-1.89)	1.44 (1.09-1.92)	6.64 (≤.05)
Joint Disorder n(%)	26 (6.45)	13 (5.14)	62 (9.95)	
Crude OR (95%CI)	1.0	0.79 (0.40-1.56)	1.60 (1.00-2.58)	7.42 (.024)
Adjusted OR (95%CI)	1.0	0.74 (0.37-1.50)	1.54 (0.93-2.55)	6.60 (≤.05)
Nerve Disorder n(%)	7(1.74)	1 (0.40)	6 (0.96)	
Crude OR (95%CI)	1.0	0.22 (0.03-1.83)	0.55 (0.18-1.65)	2.79 (.248)
Adjusted OR (95%CI)	1.0	0.22 (0.03-1.94)	0.51 (0.16-1.66)	2.82 (≥.10)

[a] Pearson chi-square, degrees of freedom = 2, used for crude OR. Maximum likelihood ratio chi-square, degrees of freedom = 2, used for adjusted OR.

[b] Variable included in the model are: age, gender, upper extremity work exposure score, disease (yes/no), prior shoulder trauma (yes/no), plant, body mass index, alcoholic drink per week, leisure time activity level.

Table 10 - Prevalance, Crude and Multiple Risk-Factor Adjusted Odds Ratios for Shoulder Disorders Determined by Physical Examination , According to Tobacco Use Status.

	Never user n = 349	Former User n = 261	Current User n = 674
Number of Cases	113 (32.38)	86 (32.95)	275 (40.80)
Crude OR (95% CI)[a]	1.0	1.03 (0.73-1.45)	1.44 (1.10-1.89)
Adjusted OR (95% CI)[b]	1.0	1.01 (0.71-1.45)	1.44 (1.07-1.92)

[a] Pearson chi-square = 8.82, p = .012, degrees of freedom = 2;
Chi-square for linear trend = 8.78, p = .003, degrees of freedom = 1.

[b] Maximum likelihood ratio chi-square = 8.223, $p \leq .05$, degrees of freedom = 2.
Variables included in the model are: age, gender, upper extremity work exposure score, disease (yes/no), prior shoulder trauma (yes/no), plant, body mass index, alcoholic drink per week, leisure time activity level.

Table 11--Prevalence, Crude and Multiple Risk-Factor Adjusted Odds Ratios of Types of Shoulder Disorders as Determined by Physical Examination, According to Tobacco Use Status .

	Never User n=349	Former User n=261	Current User n=674	X^2 (p value)[a]
Muscle-Tendon Disorder n(%)	109(31.23)	85(32.69)	262(39.05)	
Crude OR (95% CI)	1.0	1.07 (0.76-1.51)	1.41 (1.07-1.86)	7.34 (.026)
Adjusted OR(95%CI)[b]	1.0	1.07 (0.74-1.53)	1.41 (1.05-1.89)	6.57 (≤.05)
Joint Disorder n(%)	23 (6.61)	11 (4.23)	67 (9.99)	
Crude OR (95% CI)	1.0	0.62 (0.30-1.31)	1.57 (0.96-2.57)	9.62 (.008)
Adjusted OR(95%C.I.)[b]	1.0	0.57 (0.27-1.22)	1.50 (0.89-2.52)	9.78(≤.01)
Nerve Disorder n(%)	7 (2.02)	1 (038)	6 (0.90)	
Crude OR (95% CI)	1.0	0.19(0.02-1.53)	0.44(0.15-1.32)	4.18 (.124)
Adjusted OR (95%CI)[b]	1.0	0.17(0.02-1.48)	0.38(0.12-1.23)	4.45(≥.10)

[a]Pearson chi-square, degrees of freedom = 2, used for crude OR. Maximum likelihood ratio chi-square, degrees of freedom = 2, used for adjusted OR.

[b]Variables included in the model are: age, gender, upper extremity, work exposure score, disease (yes/no), prior shoulder trauma (yes/no), plant, body mass index, alcoholic drinks per week, leisure time activity level.

Table 12-Crude and Multivariate Adjusted Association Between Cigarette Pack-Year History (per 10 year increments) and Musculoskeletal Shoulder Disorders.

	Coefficient	P Value[a]	Odds Ratio	95 % CI
A. Shoulder Disorder Determined by Questionaire				
Crude				
All Subjects	.0843	.017	1.09	1.02-1.17
Former Smokers	.0630	.279	1.07	0.95-1.19
Current Smokers	.1014	.014	1.11	1.02-1.20
Adjusted[b]				
All Subjects	.0749	.050	1.08	1.00-1.16
Former Smokers	.0459	.480	1.05	0.99-1.19
Current Smokers	.1067	.017	1.11	1.02-1.22
B. Shoulder Disorder Determined by Physical Examination				
Crude				
All Subjects	.0568	.049	1.06	1.00-1.12
Former Smokers	.1176	.014	1.13	1.02-1.24
Current Smokers	.0388	.252	1.04	0.97-1.11
Adjusted[b]				
All Subjects	.0545	.082	1.06	0.99-1.12
Former Smokers	.1120	.029	1.12	1.01-1.24
Current Smokers	.0352	.344	1.04	0.96-1.11

[a] Maximum likelihood ratio chi-square, degrees of freedom =1

[b] Variables included in the model are: age, gender, upper extremity, work exposure score, disease (yes/no), prior shoulder trauma (yes/no), plant, body mass index, alcoholic drinks per week, leisure time activity level.

Table 13-Crude and Multivariate Adjusted Association Between the Number of Cigarettes Smoked Per Day (per 10 Cigarette Increments) and Musculoskeletal Shoulder Disorders

	Coefficient	P value[a]	Odds Ratio	95 % CI
A. Shoulder Disorder Determined by Questionaire				
Crude	.1459	.021	1.16	1.02-1.31
Adjusted[b]	.1787	.009	1.20	1.05-1.37
B. Shoulder Disorder Determined by Physical Examination				
Crude	.0806	.108	1.08	0.98-1.20
Adjusted[b]	.0945	.082	1.10	0.99-1.22

[a] Maximum likelihood ratio chi-square, degrees of freedom =1

[b]Variables included in the model are: age, gender, upper extremity, work exposure score, disease (yes/no), prior shoulder trauma (yes/no), plant, body mass index, alcoholic drinks per week, leisure time activity level.

STUDY 2: EFFECT OF CIGARETTE SMOKING ON THE INCIDENCE OF MUSCULOSKELETAL DISORDERS IN SENIOR MILITARY OFFICERS

METHODS

Design

The second study of this project was a prospective cohort study that examined the effects of cigarette smoking on the incidence of all musculoskeletal disorders and of lower extremity musculoskeletal disorders in a group of senior military officers. These officers were followed for a ten-month period while they attended the U.S. Army War College.

The study involved the secondary analysis of selected data previously collected for three other studies on these subjects. One study was a Physical Fitness Assessment that directly measured various components of physical fitness. The objective of that study was to provide demographic information on the physical fitness of U.S. Army senior officers. The second study, Epidemiology of Injuries and Illnesses in Senior Military Officers, abstracted information from medical records on the types of illnesses and injuries in senior military officers during their 10-month period at the Army War College. The third study was a self-administered Health Risk Appraisal designed to advise individual military officers of their predicted risk of

death and major illness during the next ten years. Although no papers have been published on the senior military officers who attended the Army War College during academic year 1991-92, the methods and results of studies on senior officers from previous classes have been reported (Knapik 1992, Knapik 1993a, Wright 1994).

Subjects

The eligible study population consisted of 222 senior military officers (all lieutenant colonels or colonels) who attended the U.S. Army War College in Carlisle Barracks, PA during the academic year August 1991 to June 1992. All 222 officers consented to participate in the three prior studies. However, the medical records of 15 subjects (7%) were unavailable for analysis. Since the medical records were required for the determination of musculoskeletal disorders, these subjects were excluded from the current study. Given the small number of women (n=9) and the need to adjust for gender, the study was restricted to men. Thus, a total of 198 male subjects were included.

Data Collection Procedures

In August 1991, at the start of the 10-month academic year, all subjects participated in a Physical Fitness Assessment. They also completed a Health Risk Appraisal and the first part of a Physical Activity and Health Questionnaire. At the end of the 10-month period, the

second part of the Physical Activity and Health Questionnaire was completed and each subject's medical records were examined.

Cigarette smoking status was determined from the self-administered Health Risk Appraisal (Appendix 10) and categorized as never smoker, current smoker, or former smoker. Subjects were considered current smokers if they smoked one or more cigarettes per day at baseline.

Questions were also asked in the Health Risk Appraisal on the number of cigars, pipes of tobacco and smokeless tobacco used per day. In addition to classification by cigarette smoking, answers to these questions were combined with the answers to questions on cigarette smoking status to categorize subjects by tobacco use (in any form) as never user, current user or former user.

Musculoskeletal injuries that occurred during the 10-month study period were determined from individual medical records examined in May 1992. The medical records were sent with the officers to be stored at the military clinic at the Army War College during the academic year. All medical visits for inpatient and outpatient services were noted in each subject's medical record. Typically, diagnoses were made by physicians or physician assistants. The records were screened for type of visit (initial or followup/recurrent), verbatim primary diagnosis, body side

and part involved, disposition (including hospitalization) and days lost to active duty. Appendix 11 presents the diagnostic and body part categories used in screening. All medical records were screened by one of two trained, experienced examiners who were blind to the research hypothesis. (One examiner had a B.S. in biology, the other a D.Sc. in applied physiology.)

Two dichotomous outcome variables were defined in the study. The first outcome was the occurrence (yes, no) during the 10-month period of one or more initial medical visits for a diagnosis consistent with a musculoskeletal disorder in any area of the body. The second outcome, a subset of the first, was initial medical visits for a diagnosis consistent with any musculoskeletal disorder of the lower extremity. The lower extremity was the body region most commonly injured in these subjects (43% of the total number of disorders).

Information on the following potential confounders was collected from the Physical Fitness Assessment (Appendix 12). Age was noted in years. Height was measured in centimeters using an anthropometer. Weight was measured in kilograms using a digital scale. Body mass index was calculated as weight divided by the square of height (kg/m^2). Self-reported information on the number of alcoholic beverages consumed in a typical week was noted in

the Health Risk Appraisal.

Maximum oxygen uptake, a measure of a person's maximal aerobic power (Astrand 1977), was part of the Physical Fitness Assessment. It was determined during a maximal treadmill stress test with walking speed set at 3.3 miles per hour and the grade increased 5% every 3 minutes until the subject was unable to continue because of fatigue. During the last minute of each grade the subject's expired air was collected into a Sensormedics Horizons Metabolic Cart and analyzed for oxygen uptake. The mean of the two highest oxygen uptake values was taken as the maximum oxygen uptake. The maximum oxygen uptake was reported in milliliters of oxygen per kilogram of body weight per minute. This collection process was supervised by a PhD level exercise physiologist.

The Physical Activity and Health Questionnaire (Appendix 13) provided information on ethnic group (classified as White, Black, or other) and leisure time activity level, assessed with a modification of the Minnesota Leisure Time Physical Activity Questionnaire (Taylor 1978; Folsom 1986). The questionnaire asked the subjects to list the physical activities in which they had participated during the 10-month study period, the number of months of participation, average days per week during the months of participation, and average duration of each

activity session. Cumulative leisure time physical activity during the 10 months was determined by multiplying the number of minutes times the number of days per week times the number of weeks of the activity. This number was converted to the number of hours during the 10-month period spent in a particular activity, which was then multiplied by estimates of the intensity of each activity (Ainsworth 1993) in units of kilocalories per kilogram of body weight per hour (Kcal/kg/hr). These calculations were summed for all activities to determine the number of kilocalories per kilogram of body weight (Kcal/kg) expended in leisure time activity during the 10 month period. Activity level during work hours was low and assumed to be similar among subjects, since all subjects attended academic classes during the 10-month period.

Data Analysis

Descriptive statistics were compiled on age, ethnic group, height, weight, body mass index, alcohol consumption, maximum oxygen uptake, leisure time activity level, and number and type of musculoskeletal disorders among never-cigarette smokers, current smokers, and former smokers. The frequency distribution of the number of musculoskeletal disorders was examined. The cumulative incidence of one or more musculoskeletal disorders and, more specifically, one or more lower extremity musculoskeletal disorders during the

10-month period were determined separately for never smokers, current smokers, and former smokers.

Chi-square tests were used to compare the proportions of subjects with musculoskeletal disorders by smoking status. Crude risk ratios with test-based 95% confidence intervals (Kleinbaum 1982) were calculated to estimate the relative risk of musculoskeletal disorders in current smokers and former smokers as compared to never smokers. Odds ratios with confidence intervals were also calculated to allow comparison with the adjusted odds ratios computed later.

Initially, subjects were stratified into quartiles on each potentially confounding variable. Stratum-specific odds ratios were examined visually and with tests of homogeneity to explore effect modification of the association between smoking and musculoskeletal disorders. However, to reduce the number of zero cells and produce more stable risk estimates, subjects were later re-stratified into tertiles on some of the potentially confounding variables. Stratum-specific odds ratios and tests of homogeneity were recalculated. Since there was little evidence of interaction, odds ratios adjusted for each potentially confounding variable were calculated.

The following steps were taken to determine whether to include continuous potential confounders as continuous or

categorical variables in the final logistic regression model. Smoking status was represented by two dummy variables for current and former smokers versus never smokers. The potential confounders were divided into tertiles. Multiple logistic regression analyses were used to determine stratum-specific odds ratios for the association between the each potential confounder and musculoskeletal disorders while controlling for smoking status. If the natural logarithms of the odds ratios indicated a linear relationship between increasing levels of the potential confounder and the incidence of disorders, the potential confounder was entered as a continuous variable in the final model. Age, body mass index, maximum oxygen uptake, and leisure time activity level (Kcal/kg) were entered as continuous variables. Alcohol consumption was divided into tertiles and entered as a categorical variable since it did not appear to have a consistent linear relationship with the incidence of musculoskeletal disorders.

With smoking status and all potential confounders forced into the logistic regression model, first-order interaction terms between smoking status and potential confounders were allowed to step into the model if significant ($p \leq .05$). No interaction terms were statistically significant. The final logistic regression

model was used to determine odds ratios for musculoskeletal disorders in current smokers and former smokers as compared to never smokers, while adjusting for age, body mass index, maximal oxygen uptake, activity level and alcoholic drinks per week.

Similar statistical methods were used to examine the association between smoking status and the incidence of lower extremity disorders. Likewise, the incidence of musculoskeletal disorders and lower extremity disorders for never tobacco users, current tobacco users, and former tobacco users were studied.

All analyses were performed using BMDP statistical computer software (BMDP Statistical Software, Inc., 1440 Sepulveda Blvd., Los Angeles, CA 90025). All reported p-values were two sided.

RESULTS

Descriptive characteristics of the subjects are presented in Table 1. Subjects were middle-aged men (mean=44 years), predominately white (92%), college graduates (100%), with many years of military service (mean= 21 years). The most popular leisure-time physical activities during the ten-month study were softball (n=173), running (n=149) and volleyball (n=140). The most time-consuming physical activities were running (11,410 hours),

golf (9622 hours) and softball (5789 hours).

Of the 198 participants in the study, 112 (56.6%) men never smoked cigarette, 64 (32.3%) were former smokers, and 22 (11.1%) were current smokers. All current smokers reported smoking 10 to 30 cigarettes per day and had a mean pack-year history of 24.3. When all types of tobacco use were considered, 104 (52.5%) men were never users, 57 (28.8%) were former users, and 37 (18.7%) were current users of tobacco products. Of the subjects who never smoked cigarettes, 1 used cigars, 1 used cigars and pipes, and 6 used smokeless tobacco. One former cigarette smoker used cigars and 6 used smokeless tobacco. One current cigarette smoker also used smokeless tobacco. Current smokers had significantly lower maximum oxygen uptake values and greater alcohol consumption than former and never cigarette smokers.

The military officers in the study suffered 72 musculoskeletal disorders to various body regions during the 10-month period (Table 2). The lower extremities were the most commonly injured region of the body (43.1%), followed in frequency by the upper extremities (33.3%) and the low back (16.7%). The frequency of musculoskeletal disorders by diagnostic category is presented in Table 3. Muscle strain (29.2%), ligament sprain (20.8%) and tendonitis (16.7%) were the most common disorders. Tables 4 and 5 show the frequency of all musculoskeletal disorders and lower

extremity musculoskeletal disorders by diagnostic category and smoking status.

Fifty-six of the subjects (28.3%) had one or more musculoskeletal disorders during the ten-month study period (Figure 1). The cumulative incidence of at least one musculoskeletal disorder was highest among current smokers (36.4%), followed by former smokers (32.8%) and never smokers (24.1%) (Table 6). Current smokers and former smokers had crude odds ratios for musculoskeletal disorders of 1.80 (95% CI=0.68-4.78) and 1.54 (95% CI=0.77-3.04) respectively, as compared to never smokers. These ratios suggest a linear increase in musculoskeletal disorder occurrence with increased cigarette use (chi-square for linear trend=2.206, p=.137). Mantel-Haenzel odds ratios for the association between cigarette smoking status and musculoskeletal disorders, adjusted individually for each potential confounder, are presented in Table 7. None of the tests of homogeneity was statistically significant (Table 7, Appendices 14-17). The control of age, body mass index, drinks per week, maximum oxygen uptake, and leisure time activity level in the logistic regression analysis increased the odds ratios for smokers and former smokers to 2.31 (95% CI=0.64-8.35) and 1.67 (95% CI=0.75-3.70) respectively, compared to never smokers.

When the use of all tobacco products was considered

(Table 8), current tobacco users had the highest cumulative incidence of musculoskeletal disorders (37.8%), followed by former tobacco users (31.6%) and never tobacco users (23.1%). The chi-square statistic for linear trend was 3.337 (p=.068). Current and former tobacco users had odds ratios for musculoskeletal disorders of 2.03 (95% CI=0.90-4.57) and 1.54 (95% CI=0.75-3.18), respectively, compared to never tobacco users. Odds ratios adjusted for multiple potential confounders were not appreciably different from the unadjusted odds ratios.

During the ten-month study period, 27 of the 198 subjects (13.6%) had one or more musculoskeletal disorders affecting the lower extremities. The cumulative incidence of lower extremity disorders was 27.3% among current smokers, 18.8% among former smokers, and 8.0% among never smokers (Table 9). Current and former smokers had odds ratios for lower extremity disorders of 4.29 (95% CI=1.34-13.8) and 2.64 (95% CI=1.04-6.71) respectively, compared to never smokers. Control of age, body mass index, drinks per week, maximum oxygen uptake, and leisure time activity level in a logistic regression analysis increased the odds ratios for current smokers and former smokers to 10.70 (95% CI=2.12-54.4) and 4.02 (95% CI=1.19-13.6), respectively, compared to never smokers. If a causal relationship is assumed between smoking and lower extremity musculoskeletal

disorder, the proportion of lower extremity disorders due to smoking in current smokers (AR%) is 90.7% (Hennekens 1987).

As with cigarette smokers, current tobacco users again had the highest percentage of subjects with lower extremity disorders and never users the lowest (Table 10). Current and former tobacco users had odds ratios for lower extremity disorders of 5.86 (95% CI=2.06-16.7) and 2.60 (95% CI=0.91-7.45), respectively, compared to never tobacco users. There was a statistically significant trend of increased risk of lower extremity disorders with more recent tobacco use (chi-square for trend=12.573 p=0.002). After controlling for potential confounders, the odds ratios for current and former tobacco users increased to 10.50 (95% CI=2.53-43.90) and 3.61 (95% CI=0.93-14.00), respectively, compared to never users.

Discussion

The frequency, location and types of musculoskeletal disorders found in this study seem to be in agreement with previous findings in the literature. The cumulative incidence of one or more musculoskeletal disorders during the ten-month study was 28.3%. This incidence rate was lower than the cumulative incidence of musculoskeletal injuries reported in infantry soldiers, but greater than the incidence of injuries reported in a civilian population.

Reynolds and associates (1994) found a 55% cumulative incidence of injuries during one year of infantry training. Knapik et al (1993b) reported a 51% cumulative incidence of all injuries and approximately 33% cumulative incidence of musculoskeletal injuries during a 6 month period in infantry soldiers. Among currently employed civilian adults, Wagener and Winn (1991) estimated that 25% had an injury requiring medical attention or restricted activity each year. The differences in incidence among these populations may be due to variations in injury definition, data collection methods and access to medical care, but may also be due to differences in exposure to physical activity. Middle-aged military officers are generally more sedentary than young soldiers in infantry training, but are more physically active with higher aerobic fitness than most individuals of a similar age (Shvartz and Reibold 1990). Increases in physical activity, such as running mileage, have been associated with increased risk of injury in civilian runners (Koplan 1982, Macera 1989) and soldiers (Jones 1993).

The lower extremity was the general body region most often affected by musculoskeletal disorders. Running, which puts considerable stress on the lower extremities, was the most time-consuming and second most popular physical activity reported by the subjects. Other physical activities that were popular, such as softball and

volleyball, also required lower extremity weight-bearing and stress. Studies of infantry soldiers (Jones 1993, Knapik 1993b, Reynolds 1994), and civilian runners (Koplan 1982, Marti 1988, Van Mechelen 1992) who performed considerable weight-bearing activities, as well a study of persons in the general population (Cunningham 1984), have found the lower extremities to be the most frequent location of musculoskeletal disorders.

Muscle strains, ligament sprains and tendonitis accounted for two-thirds of the musculoskeletal disorders in the study. Studies of injuries in infantry soldiers reported nonspecific musculoskeletal pain, muscle strains and ligament sprains among the three most often cited diagnoses (Knapik 1993b, Jones 1993, Reynolds 1994). In a study of runners, Marti et al (1988) noted pain, tendonitis and ligament sprains as being the three most frequently occurring musculoskeletal conditions.

The results of this study suggest a weak association between musculoskeletal disorders occurring throughout the body and cigarette smoking. Although the findings were not statistically significant at the level of $p=0.05$ in this relatively small study, a trend of increased risk of all musculoskeletal disorders with more recent cigarette and tobacco use was noted. Current smokers had 2.3 times and former smokers had 1.7 times the odds of musculoskeletal

disorders compared to never smokers, after controlling for potential confounders. The adjusted odds ratios for musculoskeletal disorders for current and former tobacco users compared to never users were similar to the adjusted odds ratios comparing current and former smokers to never smokers. However, there were more current users of tobacco in all forms than current cigarette smokers, so there was greater statistical power to evaluate the linear trend by user status.

Only one study has been identified that specifically examined the association between smoking and musculoskeletal disorders of all body regions combined. Infantry soldiers who smoked 1 to 10 cigarettes and those who smoked more than 10 cigarettes within the past year had 1.6 and 1.7 times the odds of having a musculoskeletal training injury, respectively, compared to nonsmokers (Reynolds 1994). The magnitude of these odds ratios are close to the values found in our study.

Two studies have noted that cigarette smokers have more acute occupational injuries as compared to nonsmokers (Ryan 1992, Naus 1966). Since many occupational injuries are musculoskeletal in nature (Hoaglund 1990), an overall association between smoking and occupational injuries suggests an association specifically with musculoskeletal disorders. These two prospective studies found a relative

risk for occupational injury of 1.4 and 1.8 respectively in smokers as compared to nonsmokers. Although they did not indicate injury type, these risk ratios are similar in magnitude to the risk ratios for musculoskeletal disorders between smokers and never smokers found in our study.

Our study found a significant positive relationship between musculoskeletal disorders affecting the lower extremities and cigarette use. Although lower extremity musculoskeletal disorders were a subset of all musculoskeletal disorder and therefore smaller in number, the results were statistically stronger. Current cigarette smokers had 10.7 times, and former smokers had 4.0 times, the odds of having one or more lower extremity musculoskeletal disorders after controlling for the potential confounders of age, body mass index, alcohol consumption, aerobic fitness level (maximum oxygen uptake) and leisure time activity level. The risks of lower extremity disorders for current and former tobacco users were similar to the risks for current and former cigarette smokers. The strong association between cigarette smoking and tobacco use and lower extremity musculoskeletal disorders may be related both to biological mechanisms and to the subjects' choice of leisure-time physical activities. Musculoskeletal structures of the lower extremities may be more sensitive to the biological effects of smoking than

structures in other regions of the body, given the lower extremities' susceptibility to peripheral vascular disease. Although the extent of leisure-time physical activity was adjusted for in the analyses, the nature of the subjects' weight-bearing physical activity likely exposed the lower extremities to more stress than other body areas, thus making them more susceptible to the ill effects of smoking.

Several recent studies also have reported a relationship between smoking and lower extremity musculoskeletal disorders. A cross-sectional study of 4054 Dutch subjects examined the relationship between smoking and self-reported pain in the back, lower and upper extremities (Boshuizen 1993). In the construction industry, the age-adjusted prevalence difference of leg pain between current smokers and never smokers was 6.0% (90% CI=1.2-10.7%), and between former smokers and never smokers was 4.9% (90% CI=0.9-8.9%). The results of our study shows a similar trend, but greater differences in the cumulative incidence for lower extremity disorders between current smokers and never smokers (19.3%, 90% CI=4.3-34.3%), and between former smokers and never smokers (12.3%, 90% CI=3.9-17.7%).

A study of 303 male U.S. Army infantry trainees found the odds ratio of lower extremity and low back injuries in individuals who smoked at least 10 cigarettes per day to be 1.9 times that of individuals who smoked less than 10

cigarettes per day (Jones 1993). The odds ratio was adjusted for age and various measures of physical fitness and activity level. A study of 181 infantry soldiers reported an odds ratio for lower extremity and lower back training injuries of 3.0 for persons who had smoked in the past year as compared to nonsmokers (Reynolds 1994). Our study, which compared current smokers to a more restricted group of never smokers and did not included disorders involving the low back, found a greater effect on the incidence of lower extremity disorders due to smoking and an intermediate effect among former smokers.

Study participants were engaged in numerous leisure-time physical activities. For example, approximately 75% of the subjects routinely ran for an average of 1.8 hours per week during the study. Although cumulative leisure-time physical activity was included in the analyses, subjects' baseline level of activity was high with considerable exposure to weight-bearing stress. The associations between cigarette and tobacco use and lower extremity disorders may be dependent on an minimal level of physical activity involving the lower extremities. The results might be different in less active populations or in subjects engaged in predominantly upper extremity physical activities.

There are several limitations to our study. While approximately 33% of the males in a 1985 U.S. national

health survey currently smoked cigarettes and 40% used at least one tobacco product (Shopland 1992), only 11% of our study participants were current smokers and 19% current users of any type of tobacco product. The small number of current smokers enrolled in the study limited the power to detect a weak association between cigarette and tobacco use and all musculoskeletal disorders combined, if one exists. The limited power of the study also affected the ability to control for multiple potential confounders in the analyses and still maintain precision in risk estimates.

Overall, study subjects were healthy, physically active, middle aged men. To remain in the military these officers had to successfully complete physical fitness requirements at regular intervals throughout their careers. Therefore a selection bias, similar to a healthy worker effect (Rothman 1986), may have influenced the results. Subjects who were potentially more sensitive to the negative health effects of cigarette and tobacco use may have previously resigned from the military and thus biased the results toward the null.

Differential misclassification of exposure and disease status was possible, but unlikely. Cigarette and other tobacco use was determined from a self-completed questionnaire and by interview. Self-reported information on smoking habits has been shown to be internally

consistent, reproducible, and accurate (Petitti 1981, Pojer 1984). Given the prospective study design, subjects and interviewers could not have known subjects' future disease status when determining smoking and tobacco exposure status.

The occurrence of one or more musculoskeletal disorders was determined from the verbatim diagnosis entered in a subject's medical record at the time of a medical visit. Standardized criteria for establishing diagnoses were not developed; instead, the health care providers' professional judgments were relied upon. It is unlikely that the health care providers differentially diagnosed musculoskeletal conditions based on subjects' smoking status. The health care providers and medical record reviewers may or may not have been blind to the subject's cigarette smoking and tobacco use, depending on the content of the records and discussion during the medical visit. However, because this study used data collected for other purposes, the subjects, interviewers, health care providers, and medical record reviewers were unaware of the study hypotheses. If misclassification occurred it was most likely nondifferential and would have reduced the association observed between smoking and musculoskeletal disorders.

The occurrence of one or more initial medical visits during the ten-month study for a diagnosis consistent with a musculoskeletal disorder was the outcome of interest.

Medical visits for follow-up care or recently (several months) recurrent episodes of similar musculoskeletal disorders were not considered. However, given the middle age of the subjects it is unlikely that these were incident episodes for musculoskeletal disorders. In this aged population the exclusion of subjects who had previously had a medical visit for any type of musculoskeletal disorder during their lifetime would have excluded most subjects.

A history of ankle sprains (Jones 1993) and lower extremity injuries and deformities (Ross 1994) has been associated with increased risk of musculoskeletal injuries during military training. The control of a previous disorder to a similar body region was considered but rejected. The smokers in this study had a mean history of 24.3 pack-years. The control of a previous musculoskeletal disorder in the design or analysis may well have resulted in the control of an intermediate step in the causal path between smoking and new episodes of disorders during the study period.

The selection of male subjects from one fairly homogeneous occupational group reduced the possible confounding effects of gender, socioeconomic status, educational background, exposure to occupational stressors, and access to medical care. Many variables believed to be associated with cigarette smoking or musculoskeletal

disorders such as age, body mass index, alcohol consumption, aerobic fitness, and leisure time activity level were included in the study. Some misclassification of potential confounders may have occurred, but it is doubtful that a history of smoking and tobacco use differentially affected the quality of information on confounders. Nondifferential misclassification of confounders would have resulted in residual confounding. Since the inclusion of multiple potential confounders in the analyses resulted in increased associations between smoking and tobacco use and musculoskeletal disorders as compared to the crude estimates, any residual confounding would have led to an underestimation of the associations.

Although this study did not focus on identifying the etiologic mechanisms for an association between cigarette smoking and musculoskeletal disorders, several hypotheses are plausible.

Carbon monoxide preferentially bonds with hemoglobin in the blood of cigarette smokers to form carboxyhemoglobin, thus reducing oxygen carried by the blood and affecting the oxygen dissociation curve so oxygen is less available to body tissues (Benowitz 1983, Guyton 1981, Becker 1990). Carbon monoxide may also bond with important extravascular proteins such as myoglobin (Becker 1990) and affect the cytochrome enzyme system (Benowitz 1983).

Hydrogen cyanide, another gas produced by the combustion of tobacco, inhibits terminal cytochrome oxidase in the respiratory chain and thus reduces the body tissues' ability to utilize oxygen (Becker 1990).

Plasma blood levels of nicotine are elevated in cigarette smokers as well as cigar, pipe, and smokeless tobacco users (US DHHS 1988; Jarvis 1984; US DHHS 1989) Nicotine stimulates the sympathetic nervous system causing vasoconstriction in the limbs, abdominal organs and heart (Benowitz 1986). Nicotine also causes depolarization at neuromuscular junctions and muscle contractions in a manner similar to acetylcholine. Moderate amounts of nicotine applied to muscle fibers is reported to cause a state of muscle spasm, while extreme amounts of nicotine causes a flaccid paralysis to occur (Guyton 1981).

The diminished ability of the blood to carry oxygen due to carbon monoxide, the impaired utilization of oxygen by tissues due to carbon monoxide and hydrogen cyanide, and the constriction of blood flow and changes in muscle tone due to nicotine may place the musculoskeletal tissues of cigarette smokers and tobacco users at greater risk for injury. The healing of musculoskeletal tissues following injury may also be compromised. These biological effects may particularly affect the musculoskeletal tissues of the lower extremities, since blood flow and transport of oxygen to the lower

extremities is more often impaired by peripheral vascular disease than the upper extremities and trunk (deWolfe 1983).

In addition, previous studies have found an association between cigarette smoking and risk-taking behaviors (Williams 1973). Cigarette smokers are reported to have more automobile accidents than nonsmokers (McGuire 1972). It is possible that cigarette smoking is wholly or in part a marker for personality traits or other behaviors that increase the risk of musculoskeletal disorders.

In conclusion, the results of this study show a significant monotonic increase in the cumulative incidence of lower extremity musculoskeletal disorders with more recent cigarette and tobacco use. A weaker, nonsignificant association was noted between cigarette and tobacco use, and musculoskeletal disorders located throughout the body. These findings are unlikely to be the result of artifact in study design or analysis, and are consistent with other epidemiologic and physiologic data. If true, they represent another important reason to avoid cigarette smoking. Additional research is needed to verify these findings and explore the causal mechanism.

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Table 1-Characteristics of 198 Senior Military Officers According to Cigarette Smoking Status. U.S. Army War College, Carlisle PA, 1991-1992.

Characteristic	All Subjects n=198 mean ± SD[a]	Never Smokers n=112 mean ± SD	Former Smokers n=64 mean ± SD	Current Smokers n=22 mean ± SD	P value[b]
Age (yrs)	43.53 ± 2.36	43.32 ± 2.31	43.67 ± 2.57	44.18 ± 1.92	0.251
Height (cm)	179.55 ± 6.53	179.37 ± 6.40	178.96 ± 7.08	179.55 ± 6.53	0.120
Weight (kg)	83.93 ± 9.52	83.08 ± 8.66	84.23 ± 10.59	83.93 ± 9.52	0.147
Body Mass Index (kg/m^2)	25.99 ± 2.22	25.80 ± 2.10	26.24 ± 2.39	26.26 ± 2.27	0.373
Drinks per week	5.53 ± 6.27	4.16 ± 5.14	7.05 ± 6.50	8.09 ± 8.90	0.015
Max O2 Uptake (ml/kg)	42.38 ± 6.47	42.77 ± 7.08	43.28 ± 5.31	37.50 ± 4.37	0.002
Physical Activity (kcal/kg)	1350.92 ± 1014.03	1278.03 ± 811. 82	1482.58 ± 1243.72	1322.80 ± 1232.11	0.457
Pack-year History		0	13.06 ± 9.79	24.32 ± 12.70	0.001
Ethnic[c]					0.180
White	183 (92.4%)	105 (93.8%)	59 (92.2%)	19 (86.4%)	
Black	10 (5.1%)	5 (4.5%)	3 (4.7%)	2 (9.1%)	
Other	5 (2.5%)	2 (1.8%)	2 (3.1%)	1 (4.5%)	

[a] SD = standard deviation
[b] continuous variables tested by analysis of variance, categorical variables tested by chi-square procedure
[c] number and column percentage

Table 2-Frequency and Percentage of 72 Musculoskeletal Disorders During 10-Month Study by Body Region

Lower Extremity	Number	(%)	Upper Extremity	Number	(%)	Other Regions	Number	(%)
Hip	2	(2.8)	Shoulder	6	(8.3)	Head	0	(0.0)
Thigh	5	(6.9)	Upper Arm	0	(0.0)	Neck	1	(1.4)
Knee	10	(13.9)	Elbow	9	(12.5)	Chest	4	(5.6)
Calf	3	(4.2)	Wrist	2	(2.8)	Abdomen	0	(0.0)
Ankle	7	(9.7)	Hand	1	(1.4)	Upper Back	0	(0.0)
Foot	3	(4.2)	Fingers	6	(8.3)	Low Back	12	(16.6)
Toes	1	(1.4)						
Total	31	(43.1)	Total	24	(33.3)	Total	17	(23.6)

Table 3-Frequency of Diagnosis of Musculoskeletal Disorders During the 10-Month Study According to Body Region

Diagnosis	Lower Extremity Number	Upper Extremity Number	Other Regions Number	Total Number (%)
Strain (muscle)	9	1	11	21 (29.2)
Sprain (ligament)	13	2	0	15 (20.8)
Tendonitis	1	11	0	12 (16.7)
Pain (nonspecific)	1	2	5	8 (11.1)
Overuse Syndrome	4	3	0	7 (9.7)
Fractures	0	3	1	4 (5.5)
Fascitis	2	0	0	2 (2.8)
Bursitis	0	1	0	1 (1.4)
Dislocation	0	1	0	1 (1.4)
Trauma	1	0	0	1 (1.4)
Totals	31 (43.1%)	24 (33.3%)	17 (23.6%)	72 100%)

Table 4-Frequency of Musculoskeletal Disorders During 10-Month Study by Diagnosis and Cigarette Smoking Status

Diagnosis	All Subjects n=198	Never Smokers n=112	Former Smokers n=64	Current Smokers n=22
Strain (muscle)	21	8	10	3
Sprain (ligament)	15	4	9	2
Tendonitis	12	8	4	
Pain (nonspecific)	8	5	3	
Overuse Syndrome	7	2	3	2
Fractures	4	3		1
Fascitis	2	1	1	
Bursitis	1	1		
Dislocation	1		1	
Trauma (nonspecific)	1		1	
Totals	72	32	32	8

Table 5-Frequency of Lower Extremity Musculoskeletal Disorders During 10-Month Study by Diagnosis and Cigarette Smoking Status

Diagnosis	All Subjects n=198	Never Smokers n=112	Former Smokers n=64	Current Smokers n=22
Strain (muscle)	9	4	3	2
Sprain (ligament)	13	5	6	2
Tendonitis	1		1	
Pain (nonspecific)	1		1	
Overuse Syndrome	4	1	1	2
Fractures	0			
Fascitis	2	1	1	
Bursitis	0			
Dislocation	0			
Trauma (nonspecific)	1		1	
Totals	31	11	14	6

Table 6-Cumulative Incidence, Crude and Multiple Risk-Factor Adjusted Odds Ratios for Musculoskeletal Disorders According to Cigarette Smoking Status

	Never Smoker n = 112	Former Smoker n = 64	Current Smoker n = 22	X^2 (p value)[a]
Number of Cases (%)	27 (24.1%)	21 (32.8%)	8 (36.4%)	
Crude OR (95% C.I.)	1.00	1.54 (0.77-3.04)	1.80 (0.68-4.78)	2.318 (0.314)[b]
Adjusted OR[c] (95% C.I.)	1.00	1.67 (0.75-3.70)	2.31 (0.64-8.35)	2.56 (0.277)

[a] Pearson chi-square, degrees of freedom = 2, used for crude OR;
Maximum likelihood ratio chi-square, degrees of freedom = 2, used for adjusted OR.

[b] Chi-square for linear trend = 2.206, degrees of freedom = 1, p = 0.137

[c] Variables included in the logistic regression model: age, body mass index, maximum oxygen uptake, leisure-time activity level and drinks per week (0-2, 3-6, ≥ 7)

Table 7-Odds Ratios of Musculoskeletal Disorders by Cigarette andTobacco Use Adjusted for Potential Confounders.

Adjusted For	Former	Homogeneity [a] (P value)	Current	Homogeneity (P Value)
A. OR's for Musculoskeletal Disorders by Smoking Status				
Crude (unadjusted)	1.67		1,80	
Age	1.51	0.308	1.81	0.681
Body Mass Index	1.53	0.304	1.92	0.798
Drinks per Week	1.44	0.460	1.69	0.636
Max Oxygen Uptake	1.69	0.166	1.62	0.136
Activity Level	1.50	0.328	2.32	0.127
B. OR's for Musculoskeletal Disorders by Tobacco Status.				
Crude (unadjusted)	1.54		2.03	
Age	1.50	0.317	2.01	0.446
Body Mass Index	1.54	0.262	1.97	0.614
Drinks per Week	1.48	0.515	1.85	0.824
Max Oxygen Uptake	1.61	0.166	1.62	0.136
Activity Level	1.53	0.350	2.30	0.382
C. OR's for Lower Extremity Musculoskeletal Disorders by Smoking Status				
Crude (unadjusted)	2.64		4.29	
Age	2.61	0.364	5.11	0.445
Body Mass Index	2.67	0.779	4.60	0.906
Drinks per Week	2.37	0.236	3.61	0.636
Max Oxygen Uptake	3.15	0.225	3.16	0.771
Activity Level	2.54	0.305	3.89	0.558

Table 7 -Continued

D. OR's for Lower Extremity Musculoskeletal Disorders by Tobacco Status.

Crude (unadjusted)	2.60		5.86	
Age	2.74	0.151	5.50	0.086
Body Mass Index	2.70	0.810	5.89	0.823
Drinks per Week	2.53	0.280	4.99	0.569
Max Oxygen Uptake	2.69	0.190	4.01	0.101
Activity Level	2.58	0.211	5.09	0.213

[a]Mantel-Haenszel test of homogeneity, degrees of freedom = 2, comparing odds ratios between levels of controlled variables

Table 8-Cumulative Incidence, Crude and Multiple Risk-Factor Adjusted Odds Ratios for Musculoskeletal Disorders According to Tobacco Use Status

	Never Users n = 104	Former Users n = 57	Current Users n =37	X^2 (p value)[a]
Number of Cases (%)	24 (23.1%)	18 (31.6%)	14 (37.8%)	
Crude OR (95% C.I.)	1.00	1.54 (0.75-3.18)	2.03 (0.90-4.57)	3.36 (0.186)[b]
Adjusted OR[c] (95% C.I.)	1.00	1.60 (0.69-3.70)	2.06 (0.75-5.67)	2.42 (0.287)

[a] Pearson chi-square, degrees of freedom = 2, used for crude OR;
Maximum likelihood ratio chi-square,degrees of freedom = 2, used for adjusted OR.

[b] Chi-square for linear trend = 3.34, degrees of freedom = 1, p = 0.068

[c] Variables included in the logistic regression model: age, body mass index, maximum oxygen uptake, leisure-time activity level and drinks per week (0-2, 3-6, ≥ 7)

Table 9-Cumulative Incidence, Crude and Multiple Risk-Factor Adjusted Odds Ratios for Lower Extremity Musculoskeletal Disorders According to Cigarette Smoking Status

	Never Smoker n=112	Former Smoker n=64	Current Smoker n=22	X^2 (p value)[a]
Number of Cases (%)	9 (8.0%)	12 (18.8%)	6 (27.3%)	
Crude OR (95% C.I.)	1.00	2.64 (1.04-6.71)	4.29 (1.34-13.8)	7.88 (0.195)[b]
Adjusted OR[c] (95% C.I.)	1.00	4.02 (1.19-13.6)	10.70 (2.12-54.4)	10.54 (0.005)

[a] Pearson chi-square, degrees of freedom = 2, used for crude OR;
Maximum likelihood ratio chi-square, degrees of freedom = 2, used for adjusted OR.

[b] Chi-square for linear trend = 7.84 degrees of freedom = 1, p=0.005

[c] Variables included in the logistic regression model are: age, body mass index, maximum oxygen uptake, leisure-time activity level and drinks per week (0-2, 3-6, ≥ 7)

Table 10-Cumulative Incidence, Crude and Multiple Risk-Factor Adjusted Odds Ratios for Lower Extremity Musculoskeletal Disorders According to Tobacco Use Status

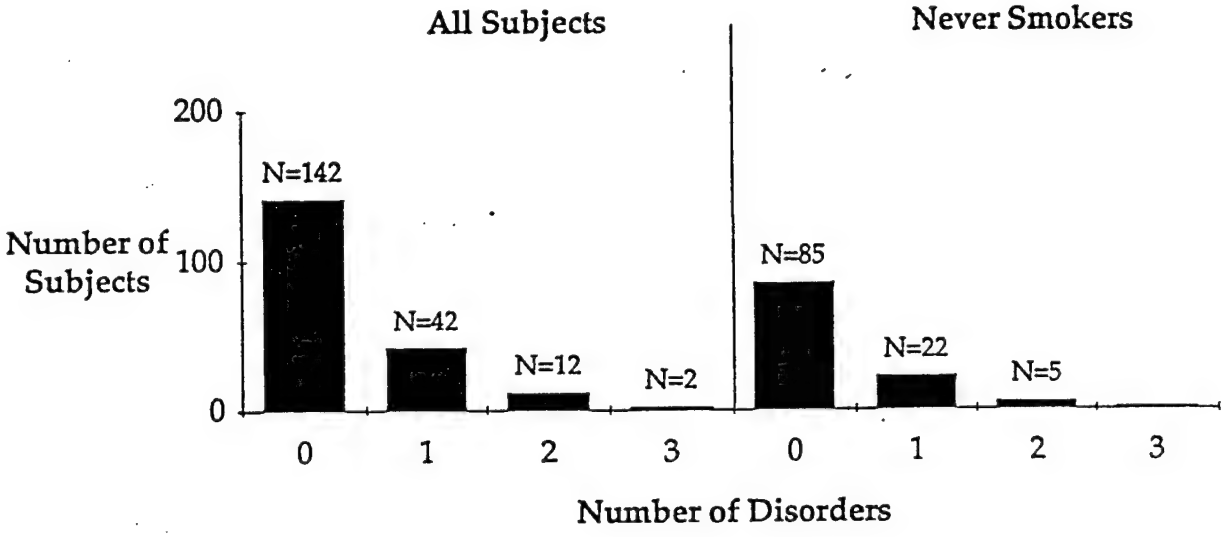
	Never User n = 104	Former User n = 57	Current User n = 37	X^2 (p value)[a]
Number of Cases (%)	7 (6.7%)	9 (15.8%)	11 (29.7%)	
Crude OR (95% C.I.)	1.00	2.60 (0.91-7.45)	5.86 (2.06-16.7)	12.57 (0.002)[b]
Adjusted OR[c] (95% C.I.)	1.00	3.61 (0.93-14.00)	10.50 (2.53-43.9)	12.16 (0.002)

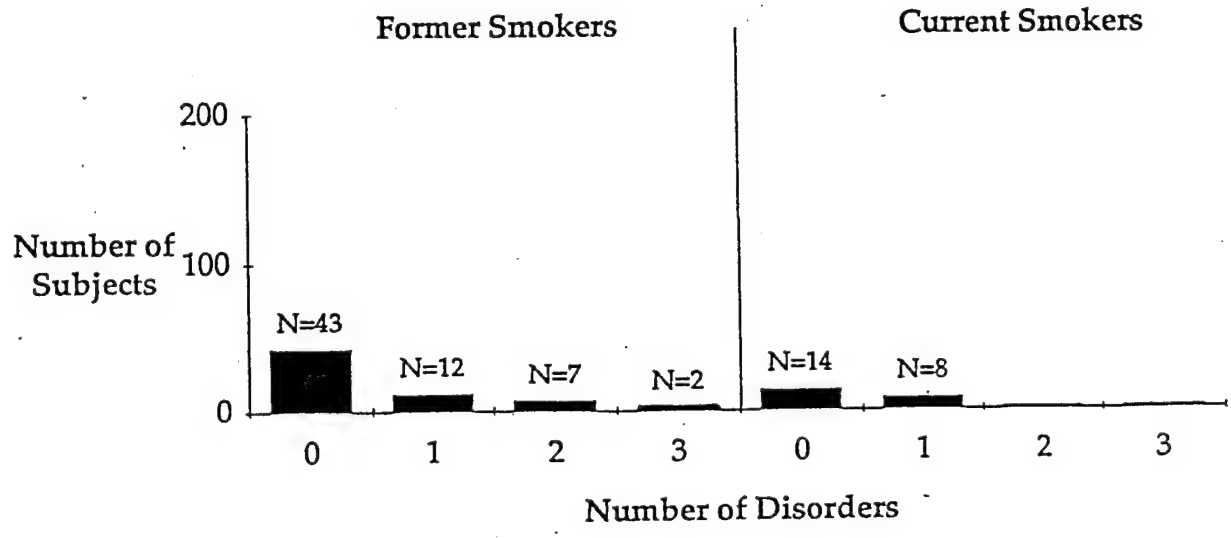
[a] Pearson chi-square, degrees of freedom = 2, used for crude OR;
Maximum likelihood ratio chi-square, degrees of freedom = 2, used for adjusted OR.

[b] Chi-square for linear trend = 12.38, degrees of freedom = 1, p = 0.0004

[c] Variables included in the logistic regression model: age, body mass index, maximum oxygen uptake, leisure-time activity level and drinks per week (0-2, 3-6, ≥ 7)

Figure 1-Frequency Distribution of Number of Musculoskeletal Disorders During Ten-Month Study Period According to Cigarette Smoking Status





STUDY 3: THE ASSOCIATION BETWEEN CIGARETTE SMOKING AND TOBACCO USE AND THE RATE OF MUSCULOSKELETAL DISORDERS IN SENIOR MILITARY OFFICERS

METHOD

Design

The third study of this project was a retrospective study that examined the effects of cigarette smoking and tobacco use on the rate of musculoskeletal disorders that occurred between 1986 and 1991 in a group of senior military officers. The medical records of a cohort of officers who attended the U.S. Army War College in 1991-92 were used to determine the numbers of all and of lower extremity musculoskeletal disorders that occurred to each person during the previous 5 years. Similar to the second study of this project, the third study involved a secondary analysis of selected data previously collected on these subjects.

Cummings, Kelsey and Nevitt (1990) discussed the difficulties that arise when studying frequent and recurrent health problems (such as falls in the elderly, motor vehicle accidents, childhood injuries, etc). They proposed that the rate of occurrence of such health problems, rather than the state of having or not having the health problem, is a more relevant outcome measure. They suggested that rate of occurrence is of greater public health importance, avoids an

arbitrary time definition of who has the health problem, and may be more sensitive to associations with risk factors than the state of having/not having a health problem. Their discussion is relevant to the topic of musculoskeletal disorders since musculoskeletal disorders are common and recurrent, with many people having multiple, transient musculoskeletal disorders during a lifetime. The third study of this project, which focuses on the frequency of disorders, provides a contrast in methods to the first two studies, which focused on the state (yes/no) of having a disorder.

Subjects

Similar to the second study of this project, the eligible study population consisted of 222 senior military officers (all lieutenant colonels or colonels) who attended the U.S. Army War College during the academic year August 1991 to June 1992. All 222 officers gave written, informed, voluntary consent to participate in the original studies in accordance with the Army Surgeon General's Guidelines (Army Regulation 70-25). The past medical records of 35 subjects (15.7%) were unavailable for analysis. Since the medical records were the source of the data on musculoskeletal disorders, these subjects had to be excluded from the study. Given the small number of women (n=9) and the need to control for the confounding effects of gender, the study was

restricted to men. Thus, a total of 178 male subjects were included in the study.

Data Collection Procedures

At the start of the academic year in August 1991 all subjects participated in a Physical Fitness Assessment and completed a Health Risk Appraisal and a Physical Activity and Health Questionnaire. During November and December 1991 each subject's complete medical record was reviewed.

Cigarette smoking history, gathered from the Health Risk Appraisal (Appendix 10), was used to determine each subject's cigarette smoking status from August 1, 1986 to August 1, 1991. Cigarette smoking status was categorized as never smoker, former smoker, recent smoker, or current smoker. Subjects were classified as former smokers if they stopped smoking before August 1, 1986, and were classified as recent smokers if they stopped smoking between August 1, 1986 and August 1, 1991. Subjects were classified as current smokers if they smoked one or more cigarettes per day during the 5-year study period and were still smoking as of August 1, 1991. Each subject's cigarette pack-year history was determined. Smoking one pack of cigarettes per day for a year equaled one pack-year.

Questions were asked on the number of cigars, pipes of tobacco, and smokeless tobacco used per day. Answers to these questions were combined with the answers to questions

on cigarette smoking status to categorize tobacco use as never user, current user, recent user, or former user.

Musculoskeletal disorders that occurred between August 1, 1986 and August 1, 1991 were determined from each subject's medical record. All medical visits for inpatient and outpatient services during an officer's military career are noted in the medical record. These records are sent with the officers to be stored at the military clinic at each new location of military service. The records were screened in November and December 1991 for type of visit (initial or followup/recurrent), diagnosis, body part or organ system involved, body side affected, and disposition (including hospitalization). Appendix 11 presents the diagnostic and body-part categories used in screening. All medical records were screened by one of two trained, experienced examiners who were blind to the research hypothesis. (One examiner had a B.S. in biology, the other a D.Sc. in applied physiology.)

A medical visit was deemed followup/recurrent if it appeared from the medical records that the visit was for a recently occurring, previously cited diagnosis to the same body region; otherwise the medical visit was deemed initial. Musculoskeletal disorders consisted of initial medical visits for diagnoses such as: muscle strain, tendonitis, ligament sprain, bursitis, dislocation, stress fracture, and

non-specific pain. No distinction was made among musculoskeletal diagnoses typically associated with an acute versus a gradual onset; all were included under the general term "musculoskeletal disorders". Integumentary disorders such as lacerations, contusions, burns, and rashes were not included.

The five-year rate of musculoskeletal disorders was estimated from the number of initial medical visits for a diagnosis consistent with a musculoskeletal disorder, for each person, during the period between August 1, 1986 and August 1, 1991, with the assumption that each officer was at risk for the entire 5-year period. The five-year rate of lower extremity musculoskeletal disorders was defined in a similar fashion for diagnoses consistent with lower extremity musculoskeletal disorders. Subjects were not prevented from contributing person-time following the occurrence of a disorder since they continued to be eligible for occurrences of musculoskeletal disorders in other body regions and new occurrences (noted as an initial medical visit) of disorders in the same body region. The contribution of 5 person-years by each subject may have resulted in a slight over-estimation of person-years in the denominator of the rate, since subjects with a disorder may have been less active and less likely to sustain another injury. An over-estimation of person-years would have

resulted in lower rates, but there was no reason to expect a differential impact by smoking status. Since each subject contributed approximately 5 person-years to the study, the annualized rates of all musculoskeletal disorders and lower extremity musculoskeletal disorders per 100 persons were calculated by multiplying the mean number of musculoskeletal disorders per person during the five-year study period by 100/5 = 20.

Information on the following potential confounders was determined from the Physical Fitness Assessment. Age in 1986 was calculated from age in 1991. Height was measured in centimeters using an anthropometer. Weight was measured in kilograms using a digital scale. Using this information, body mass index was calculated as weight divided by the square of height (kg/m^2). Height, weight, and body mass index were collected in 1991 and assumed to be the same as those in 1986.

The Physical Activity and Health Questionnaire provided information on ethnic group and physical activity level. Ethnic group was classified as White, Black, or other. Physical activity level was assessed with a self-rating of physical activity upon entrance to the U.S. War College in 1991. Physical activity was rated as: 0 (very inactive), 1 (somewhat inactive), 2 (average), 3 (active), and 4 (very active).

Self-reported information on the number of alcoholic beverages consumed in a typical week was determined from the Health Risk Appraisal. Marital status was also obtained from that source. Information on alcohol consumption, marital status and physical activity, collected in 1991, was assumed to be constant for the time period between 1986 and 1991.

Data Analysis

Descriptive statistics were compiled on age, height, weight, body mass index, ethnic group, alcohol consumption, physical activity level, and number and type of musculoskeletal disorders.

The numbers of all and of lower extremity musculoskeletal disorders per person during the five-year study period were determined for never, former, recent and current cigarette smokers. The mean, median, range, and tenth and ninetieth percentiles of the numbers of all and lower extremity musculoskeletal disorders for the cigarette smoking groups were also determined. Since the mean number of musculoskeletal disorders per person among recent and current cigarette smokers were similar (both means=1.00) and the number of subjects in these two groups were small (recent smokers n=10, current smokers n=17), these two groups were combined and identified as current smokers in all subsequent data analyses to improve the statistical

power of the study.

Because the frequency distributions of the numbers of all and lower extremity musculoskeletal disorders were skewed to the right, with the majority of subjects having none or one disorder, the data were analyzed in several ways. The Kruskal-Wallis test, a nonparametric analysis of variance that examines rank-order, was used to determine if there were significant differences in the frequency of all and lower extremity musculoskeletal disorders among the cigarette smoking groups.

Parametric statistical tests, which are usually more powerful than nonparametric tests and allow the calculation of crude and adjusted rates, were also included. Analysis of variance procedures were used to examine differences in the mean numbers of all and of lower extremity disorders among the smoking groups. Analysis of variance procedures are reported to be robust with respect to violations of normality (Dawson-Saunders 1990). However, an additional approach was used to improve the normality of the data: 0.5 was added to the numbers of disorders for each subject and were log transformed in order to repeat the analyses of variance.

Possible confounding and effect modification of the association between cigarette smoking and the rate of musculoskeletal disorders by other factors were explored

with analysis of covariance procedures. Linear regression models with the number of all or lower extremity musculoskeletal disorders as the dependent variable and individual potential confounders as the independent variable were fit for each cigarette smoking group (never, former, current). The potential confounders were entered as continuous variables since they exhibited a linear relationship when categorized into quartiles with the number of disorders. The slopes of the regression lines were compared visually and statistically for equality (parallelism) among the cigarette smoking groups to search for possible interactions between cigarette smoking status and each potential confounder. The mean number of musculoskeletal disorders and mean number of lower extremity disorders per person during the five-year study, adjusted for each potential confounder and adjusted for multiple confounders was calculated. The same parametric approach was used to evaluate confounding and effect modification with the log transformations of the number of all and lower extremity disorders as dependent variables.

Similar descriptive statistics, Kruskal-Wallis tests, analyses of variance, tests of parallelism, analyses of covariance, and multiple linear regressions were used to compare never, current, and former tobacco users.

All analyses were performed using BMDP statistical

computer software (BMDP Statistical Software, Inc., 1440 Sepulveda Boulevard, Suite 316, Los Angeles, CA 90025). All reported p- values were two sided.

RESULTS

The characteristics of the 178 subjects who participated in the study are presented in Tables 1 and 2. Subjects were middle aged men (mean=38 years), predominately white (93%), married (92%), and college graduates (100%). All subjects were lieutenant colonels (80%) or colonels (20%), with an average of 16 years of military service at the beginning of the study in 1986. Of the 178 subjects, 104 (58.4%) were never cigarette smokers, 47 (26.4%) were former smokers, and 27 (15.2%) were current smokers in 1986. When all types of tobacco use were considered 96 men (53.9%) were never users, 42 (23.6%) were former users and 40 (22.5%) were current users of tobacco products.

Descriptive characteristics of the 35 subjects who were excluded because of missing medical records are found in Table 1. Although there were no significant differences between these 35 subjects and the 178 subjects included in the study, the data suggest that excluded subjects were more likely to be former or current cigarette smokers, to be former or current tobacco users, to have a greater cigarette pack-year history, and to drink fewer alcoholic beverages

per week than study participants.

The frequency of musculoskeletal disorders that occurred in the military officers during the five-year study period is presented by body regions in Table 3. The lower extremities were the most commonly injured region of the body (41.7% of all disorders), following in frequency by the upper extremities (24.7%) and the lower back (23.9%). Table 4 shows the frequency of musculoskeletal disorders according to diagnostic categories. Non-specific pain (29.6%), muscle strains (26.7%), tendonitis (11.3%) and ligament sprains (10.9%) were the most common diagnoses.

The 178 military officers included in the study had a total of 247 musculoskeletal disorders during the five-year study period, for a mean of 1.39 disorders per person, and an annualized rate of 27.8 disorders per 100 person-years. The frequency distribution of the number of musculoskeletal disorders among the cigarette smoking groups is shown in Figure 1. Never, former, and current smokers had means of 1.51, 1.34 and 1.0 disorders respectively. Although there was a trend of decreasing frequency of disorders associated with smoking, there were no statistically significant differences in the frequency distribution, the mean number, or mean log of the number of musculoskeletal disorders among the three cigarette smoking groups (Table 5). Control of age, body mass index, drinks per week and physical activity

rating in the analyses of covariance did not appreciably change the results (Tables 6 and 7).

When the use of all tobacco products was considered and subjects were classified into never, former, and current tobacco users, the results were similar to the results comparing the cigarette smoking groups. There were no significant differences in the crude and adjusted mean number of musculoskeletal disorders per person during the five years among tobacco use groups (Tables 5-7).

During the five-year study period, there were 103 lower extremity disorders among the 178 officers for a mean of 0.58 lower extremity disorders per person, and an annualized rate of 11.6 disorders per 100 person-years. Never smokers had an average of 0.74 lower extremity musculoskeletal disorders per person during the five years, while former smokers averaged 0.38 and current smokers averaged 0.30 lower extremity disorders (Table 8). These findings were nonsignificant but suggest a weak protective effect of cigarette smoking for lower extremity musculoskeletal disorders. However, when the mean number and mean log of the number of lower extremity disorders were adjusted for age, body mass index, drink per week, and physical activity rating, the differences among the cigarette smoking groups diminished (Tables 9 and 10).

The number of lower extremity disorders during the

five-year study were also compared among never, former, and current tobacco users (Tables 8-10). There were no significant differences in the crude and adjusted mean number and mean log of the number of lower extremity musculoskeletal disorders per person during the five years among tobacco use groups.

DISCUSSION

This study determined the frequency of musculoskeletal disorders in senior military officers and examined the relationship of these disorders with cigarette and tobacco use. No clear evidence of such a relationship was found.

The rate of musculoskeletal disorders during the five year study was 1.39 disorders per person, which is equivalent to an annualized rate of 27.8 musculoskeletal disorders per 100 person-years. This annual rate of musculoskeletal disorders in senior military officers is considerably less than the rate in younger, more physically active infantry soldiers. Knapik et al (1993) reported an annual rate of 93 musculoskeletal disorders per 100 male infantry soldiers using a similar definition of disorders and method of data collection. Tomlinson and associates (1987) found an overall rate of 81 acute and overuse injuries (all types) per 100 active duty soldiers and an annual rate of 52 musculoskeletal injuries (sprains,

fracture, pain, and low back strain) per 100 active duty soldiers. The rates in the Tomlinson study were determined from male and female active duty soldiers at a large army base which included soldiers in infantry combat training as well as more sedentary occupations.

The annual rate of musculoskeletal disorders in our study was slightly higher than rates reported in civilian populations. Wagener and Winn (1991), in a study using data from the National Health Interview Survey, found an overall annual rate of 26.42 disorders per 100 currently employed persons between the ages of 18 to 64 years. Rates in the subgroup of persons currently employed in white collar jobs earning more than $20,000 per year were 21.31 injuries per 100 persons. While this subgroup offered the closest comparison to the senior military officers in our study, the rates reported by Wagner and Winn included a wider range of injuries than our study which focused on musculoskeletal disorders. The higher rate of disorders in the senior military officers may be due to greater physical activity than civilian populations. Sixty-two percent of the officers rated themselves more active than average on the physical activity rating scale. Increases in physical activity such as running mileage has been associated with increased risk of injury in civilian runners (Koplan 1982, Macera 1989) and soldiers (Jones 1993).

The lower extremities were the general body region most frequently affected (41.7%) by musculoskeletal disorders. Among the lower extremities, the knee (15.0%) followed by the tibial area (calf and shin 13.3%) were most often involved. Studies on infantry soldiers (Jones 1993, Knapik 1993, Reynolds 1994) and civilians engaged in weight bearing recreational activities (Koplan 1982, Marti 1988, van Mechelen 1992) reported an even greater percent of lower extremity disorders. The most frequently cited specific location of lower extremity disorders varied from study to study. Cunningham and Kelsey (1984) used data from the US Health and Nutrition Examination Survey of 1971-1975 on noninstitutionalized adults ages 25 to 74 years; they found the most frequent location of musculoskeletal disorders to be the lower extremities, followed by the upper extremities and back. When specific body regions were considered, the back (15-17%) and knee (12-15%) were most often noted. We also found a considerable number of musculoskeletal disorders affecting the low back (23.9%), which was not surprising given the age of the military officers in our study. The peak incidence of low back pain occurs in the third and fourth decade of life (Hoaglund 1990).

The four most frequently reported diagnoses for musculoskeletal disorders were pain (nonspecific), muscle strain, tendonitis, and ligament sprains. Although

comparison is difficult, given the lack of reporting specific diagnoses or the variety of diagnostic criteria used in other studies, our results appear to be consistent with previous findings. Studies of disorders in infantry soldiers reported musculoskeletal pain, muscle strain and ligament sprain among the three most frequently cited diagnoses (Knapik 1993, Jones 1993, Reynolds 1994). In a study of runners, Marti et al (1988) specified pain, tendonitis and ligament sprain as being the three most frequently occurring musculoskeletal disorders.

Our study did not find a significant positive association between cigarette smoking or tobacco use and the rate of musculoskeletal disorders, either throughout the body or confined to the lower extremities. Cigarette and tobacco use did not increase the risk of musculoskeletal disorders or lower extremity disorders; in fact, current cigarette smokers had the lowest rate of disorders as compared to former and never smokers.

These findings were unexpected. Study 1 of this dissertation found cigarette and tobacco users to have a greater prevalence of musculoskeletal shoulder disorders than never users. Study 2 noted an association between the incidence of lower extremity musculoskeletal disorders and cigarette and tobacco use. Although the relationship between cigarette and tobacco use and musculoskeletal

disorders has not been thoroughly explored, many studies have found a positive association between smoking and lower extremity musculoskeletal injuries (Reynolds 1994, Jones 1993), leg pain (Boskuizen 1993), low back pain (Frymoyer 1980, Frymoyer 1983, Biering-Sorensen 1986, Saraste 1987, Deyo 1989, Battie 1989, Heliovaara 1991, Svensson 1993, Boshuizen 1993) and occupational injuries (Naus 1966, Ryan 1992).

In contrast, several studies have found a protective association between smoking and osteoarthritis (Anderson and Felson 1988, Felson 1989, Kraus 1978, Typpo 1985). However, it is unlikely that our subjects, who had a mean age of 38 years and were younger than persons usually affected by osteoathritis, had a high prevalence of osteoarthritis that substantially increased the rate of musculoskeletal disorders in never smokers.

It is possible that cigarette smokers may seek medical care for musculoskeletal disorders less often than never smokers. Cigarette smokers may be less health conscious and avoid the health care system, which often urges smoke cessation, unless the musculoskeletal disorder is severe. Since the frequency of musculoskeletal disorders was determined from the frequency of initial medical visits for diagnoses consistent with musculoskeletal disorders, differences in health care utilization by smoking status may

have contributed to the results.

Cohort studies are sometimes affected by the non-participation of members of the cohort, or by loss of subjects to follow-up. This loss may have affected the results of the study. Thirty five (16%) of the eligible subjects in the cohort were excluded from the study because their medical records, which are kept at the base medical clinic, were unavailable for screening. The medical records were needed to determine the occurrence of musculoskeletal disorders. There were several reasons why a medical record might be unavailable: the officer did not turn in his medical record to the clinic, the officer was sent to another medical facility for specialized care at the time of screening, or the record was missing within the clinic at the time of screening. It is likely that the officers excluded for unavailable medical records had poorer health than study participants and may have had a greater number of musculoskeletal disorders. In fact, the annual rate of musculoskeletal disorders for the 174 subjects included in this 5-year study period (27.8 disorders per 100 person-years) was considerably less than the annual rate for the 198 subjects included in the later 10-month period for Study 2 (43.6 disorders per 100 person-years). This difference in annual rates between the two studies may also reflect a difference in activity level and access to medical care

during the two study periods. A larger percentage of the excluded officers were current cigarette smokers and had a greater pack-year history than study participants.

The exclusion of subjects who were more likely to have musculoskeletal disorders and be cigarette smokers may have contributed to the small number of musculoskeletal disorders in participating smokers. If each of the excluded subjects had 2 musculoskeletal disorders during the 5 year study, never cigarette smokers would have had a mean of 1.58 disorders per person, while former and current smokers would have had means of 1.47 and 1.18 disorders, respectively. To find a positive association between smoking and musculoskeletal disorders each of the excluded never smokers would have had to have had 0 disorders, the excluded former smokers 2 disorders, and the excluded current smokers 4 disorders. This situation would have resulted in means of 1.29, 1.47 and 1.55 disorders among never, former and current smokers, respectively.

Differential misclassification of exposure and disease status was possible, but unlikely. Cigarette and other tobacco use was determined from a self-completed questionnaire and by interview. Self-reported information on smoking habits has been shown to be internally consistent, reproducible, and accurate (Petitti 1981, Pojer 1984). Interviewers were blind to subjects' medical history

when determining smoking and tobacco exposure status.

The occurrence of musculoskeletal disorders was determined from the verbatim diagnosis entered in a subject's medical record at the time of a medical visit. Standardized criteria for establishing diagnoses were not developed; rather, the health care providers' professional judgments were relied upon. The health care providers and medical record reviewers may or may not have known a subject's cigarette smoking and tobacco status, depending on the content of the records and discussion during the medical visit. However, because this study used data collected at an earlier time and for other purposes, the subjects, interviewers, health care providers, and medical record reviewers were unaware of the study hypotheses. If misclassification occurred it was most likely random and would have reduced an association between cigarette smoking and musculoskeletal disorders.

The selection of male subjects from one fairly homogeneous occupational group reduced the possible confounding effects of gender, socioeconomic status, educational background, and access to medical care, but limits generalization of the results to other populations. Many variables believed to be associated with cigarette smoking or musculoskeletal disorders such as age, body mass index, alcohol consumption, and physical activity were

included in the study. Some misclassification of potential confounders may have occurred since body mass index, alcohol consumption, and physical activity rating collected in 1991 was assumed to be the same as in 1986. However, it is doubtful that a history of smoking and tobacco use differentially affected the quality of information on confounders. Random misclassification of confounders would have resulted in residual confounding. The inclusion of multiple potential confounders in most analyses minimally reduced the differences in the number of musculoskeletal disorders among smoking status groups as compared to crude values. Therefore, residual confounding most likely would have biased the results away from the null.

In conclusion, this study found no significant difference in the number of musculoskeletal disorders or lower extremity musculoskeletal disorders over a five year period among never, former and current users of cigarettes and tobacco products. Subjects were physically active, generally healthy, middle aged men. Further research is needed to support or repudiate these findings in similar and other populations.

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Table 1-Characteristics of 178 Included and 35 Excluded Senior Military Officers (Excluded from the Study due to Missing Medical Records) U.S. Army War College, Carlisle PA, 1991-92

Characteristics	Included Subjects	Excluded Subjects	P Value [a]
	Mean ± SD [b]	Mean ± SD	
Age (yrs)	38.3 ± 2.4	39.3 ± 2.15	0.903
Heights (cm)	179.7 ± 6.4	180.0 ± 7.03	0.542
Weight (kg)	83.9 ± 9.7	82.7 ± 8.33	0.284
Body Mass Index (kg/m^2)	25.9 ± 2.3	25.5 ± 1.96	0.455
Physical Activity Rating [c]	2.7 ± 1.1	2.2 ± 1.17	0.723
Drinks per Week	5.8 ± 6.6	4.8 ± 4.65	0.156
median (10-90%) [d]	4 (0-14)	4 (0-12	
Pack-Years	6.6 ± 10.7	7.9 ± 2.4	0.146
median (10-90%)	0 (0-22)	0 (0-27)	
	n (%)	n (%)	
Cigarette Use			0.746
Never	104 (58.4)	18 (51.4)	
Former	47 (26.4)	11 (31.4)	
Current	27 (15.2)	6 (17.2)	
Tobacco Use			0.668
Never	96 (53.9)	16 (45.7)	
Former	42 (23.6)	10 (28.6)	
Current	40 (22.5)	9 (25.7)	
Ethnic Group			0.311
White	166 (93.3)	32 (91.4)	
Black	9 (5.0)	1 (2.9)	
Other	3 (1.7)	2 (5.7)	

[a] Continuous variables tested by analyses of variance; categorical variables tested by chi-square procedures

[b] SD = standard deviation

[c] Physical activity rating: 0 = very inactive, 1 = somewhat inactive, 2 = average, 3 = active, 4 = very active.

[d] Median with 10^{th} to 90^{th} percentiles in parentheses.

Table 2-Characteristics of 178 Senior Military Officers According to Cigarette Smoking Status. U.S. Army War College, Carlisle PA, 1991-92

Characteristics	Never Smokers n=104	Former Smokers n=47	Current Smokers n=27	P Value [a]
	Mean ± SD [b]	Mean ± SD	Mean ± SD	
Age (yrs)	38.2 ± 2.3	38.5 ± 2.7	38.5 ± 1.8	0.643
Heights (cm)	179.6 ± 6.3	179.2 ± 7.1	181.1 ± 5.3	0.459
Weight (kg)	82.7 ± 8.9	84.7 ± 10.7	87.0 ± 0.4	0.092
Body Mass Index (kg/m^2)	25.6 ± 2.2	26.3 ± 2.4	26.5 ± 2.4	0.082
Physical Activity Rating [c]	2.8 ± 1.1	2.6 ± 1.2	2.5 ± 0.9	0.462
Drinks per Week	4.4 ± 5.5	7.6 ± 7.2	8.0 ± 8.0	0.003
median (10-90%) [d]	2 (0-10)	6 (0-20)	6 (1-14)	
Pack-Years	0 ± 0	11.9 ± 8.7	22.4 ± 2.6	0.0005
median (10-90%)	0 (0-0)	10 (4-23)	20 (7-39)	
	n (%)	n (%)	n (%)	
Ethnic Group				0.282
White	99 (95.2)	43 (91.5)	24 (88.9)	
Black	4 (3.8)	2 (4.3)	3 (11.1)	
Other	1 (1.0)	2 (4.3)	0	

[a] Continuous variables tested by analyses of variance; categorical variables tested by chi-square procedures

[b] SD = standard deviation

[c] Physical activity rating: 0 = very inactive, 1 = somewhat inactive, 2 = average, 3 = active, 4 = very active.

[d] Median with 10^{th} to 90^{th} percentiles in parentheses.

Table 3-Frequency of 247 Musculoskeletal Disorders During the Five-Year Study According to Body Region

Lower Extremity	Number	(%)	Upper Extremity	Number	(%)	Other Regions	Number	(%)
Hip	5	(2.0)	Shoulder	19	(7.7)	Neck	8	(3.2)
Thigh	8	(3.2)	Upper Arm	5	(2.0)	Chest	13	(5.3)
Knee	37	(15.0)	Elbow	11	(4.5)	Abdomen	2	(0.8)
Calf	26	(10.5)	Lower Arm	5	(2.0)	Upper Back	1	(0.4)
Shin	7	(2.8)	Wrist	2	(0.8)	Lower Back	59	(23.9)
Ankle	6	(2.4)	Hands	4	(1.6)			
Foot	11	(4.5)	Fingers	14	(5.7)			
Toes	3	(1.2)	Multiple Sites	1	(0.4)			
Total =	103	(41.7%)	Total =	61	(24.7%)	Total =	83	(33.6%)

Table 4-Frequency of Diagnosis of Musculoskeletal Disorders During the Five-Year Study According to Body Region

Diagnosis	Lower Extremity Number	Upper Extremity Number	Other Regions Number	Totals Number (%)
Pain (nonspecific)	18	9	46	73 (29.6)
Strain (muscle)	23	7	36	66 (26.7)
Tendonitis	11	17	0	28 (11.3)
Sprain (ligament)	22	5	0	27 (10.9)
Trauma	3	11	1	15 (6.1)
Overuse	10	0	0	10 (4.0)
Bursa	5	5	0	10 (4.0)
Fracture	4	5	0	9 (3.6)
Fascia	4	0	0	4 (1.6)
Stress Reaction	3	0	0	3 (1.2)
Dislocation	0	2	0	2 (0.8)
Totals	103 (41.7%)	61 (24.7%)	83 (33.6%)	247 (100%)

Table 5-Number of Musculoskeletal Disorders Per Person During Five-Year Study According to Cigarette and Tobacco Use Status

	Cigarette Smoking Status					
	Never n=104	Former n=47	Current n=27	Kruskal-Wallis P Value	ANOVA[a] P Value	ANOVA[b] P Value
Total no.	157	63	27	0.541	0.359	0.455
Range	1-10	0-6	0-3			
10-90%[c]	0-4	0-4	0-3			
Median	1.00	1.00	1.00			
Mean	1.51	1.34	1.00			
SD[d]	1.84	1.49	1.11			

	Tobacco Use Status					
	Never n=96	Former n=42	Current n=40	Kruskal-Wallis P Value	ANOVA P Value	ANOVA P Value
Total no.	147	58	42	0.682	0.309	0.626
Range	0-10	0-6	0-3			
10-90%	0-4	0-4	0-3			
Median	1.0	1.0	1.0			
Mean	1.53	1.38	1.05			
SD	1.90	1.53	1.06			

[a] ANOVA=analysis of variance of mean numbers of disorders among differing use groups
[b] ANOVA=analysis of variance of mean log of numbers of disorders among differing use groups
[c] 10-90% = 10th to 90th percentiles
[d] SD = standard deviation

Table 6-Crude and Adjusted Number of Musculoskeletal Disorder per Person During Five-Year Study According to Cigarette and Tobacco Use Status

Confounders	Cigarette Smoking Status			ANOVA[b]
	Never Mean ± SD[a]	Former Mean ± SD	Current Mean ± SD	P Value
Crude	1.51 ± 1.84	1.34 ± 1.49	1.00 ± 1.11	0.359
Age (years)	1.52 ± 1.63	1.33 ± 1.65	0.98 ± 1.66	0.312
Body Mass Index	1.52 ± 1.67	1.33 ± 1.67	0.98 ± 1.67	0.316
Drinks per Week	1.50 ± 1.69	1.36 ± 1.69	1.02 ± 1.66	0.435
Physical Activity[c]	1.56 ± 1.70	1.36 ± 1.69	1.07 ± 1.69	0.408
Multivariate	1.56 ± 1.73	1.35 ± 1.72	1.07 ± 1.72	0.455
Confounders	Tobacco Use Status			ANOVA
	Never Mean ± SD	Former Mean ± SD	Current Mean ± SD	P Value
Crude	1.53 ± 1.90	1.38 ± 1.53	1.05 ± 1.06	0.309
Age (years)	1.53 ± 1.66	1.35 ± 1.67	1.08 ± 1.66	0.345
Body Mass Index	1.54 ± 1.66	1.37 ± 1.67	1.03 ± 1.68	0.269
Drinks per Week	1.52 ± 1.70	1.39 ± 1.67	1.07 ± 1.71	0.398
Physical Activity	1.56 ± 1.70	1.39 ± 1.69	1.14 ± 1.68	0.470
Multivariate	1.54 ± 1.75	1.37 ± 1.71	1.21 ± 1.76	0.635

[a] SD = Standard Deviation

[b] ANOVA = Analysis of Variance for crude means; analysis of covariance for adjusted mean

[c] Physical activity rating: 0=very inactive, 1=somewhat inactive, 2=average, 3=active, 4=very active

Table 7-Crude and Adjusted Log of Number of Musculoskeletal Disorder per Person During Five-Year Study According to Cigarette and Tobacco Use Status

Confounders	Cigarette Smoking Status			ANOVA[b]
	Never Mean ± SD[a]	Former Mean ± SD	Current Mean ± SD	P Value
Crude	0.15 ± 0.37	0.12 ± 0.36	0.05 ± 0.34	0.455
Age (years)	0.17 ± 0.36	0.12 ± 0.36	0.06 ± 0.36	0.381
Body Mass Index	0.17 ± 0.36	0.12 ± 0.36	0.06 ± 0.36	0.389
Drinks per Week	0.16 ± 0.37	0.12 ± 0.37	0.07 ± 0.37	0.488
Physical Activity[c]	0.16 ± 0.36	0.12 ± 0.36	0.07 ± .0.36	0.476
Multivariate	0.17 ± 0.37	0.12 ± 0.36	0.06 ± 0.37	0.434
Confounders	Tobacco Use Status			ANOVA
	Never Mean ± SD	Former Mean ± SD	Current Mean ± SD	P Value
Crude	0.15 ± 0.38	0.13 ± 0.37	0.08 ± 0.32	0.626
Age (years)	0.16 ± 0.36	0.12 ± 0.36	0.10 ± 0.36	0.702
Body Mass Index	0.16 ± 0.37	0.13 ± 0.36	0.09 ± 0.37	0.630
Drinks per Week	0.16 ± 0.37	0.13 ± 0.37	0.10 ± 0.37	0.759
Physical Activity	0.16 ± 0.37	0.13 ± 0.36	0.10 ± 0.37	0.745
Multivariate	0.16 ± 0.38	0.12± 0.39	0.11 ± 0.38	0.800

[a] SD = Standard Deviation
[b] ANOVA = Analysis of Variance for crude means; analysis of covariance for adjusted mean
[c] Physical activity rating: 0=very inactive, 1=somewhat inactive, 2=average, 3=active, 4=very active

Table 8-Number of Lower Extremity Disorders Per Person During Five-Year Study According to Cigarette and Tobacco Use Status

	Cigarette Smoking Status					
	Never n=104	Former n=47	Current n=27	Kruskal-Wallis P Value	ANOVA[a] P Value	ANOVA[b] P Value
Total no.	77	18	8	0.176	0.069	0.111
Range	0-8	0-2	0-2			
10-90%[c]	0-2	0-1	0-1			
Mean	0.74	0.38	0.30			
SD[d]	1.35	0.61	0.61			
Median	0	0	0			
	Tobacco Use Status					
	Never n=96	Former n=42	Current n=40	Kruskal-Wallis P Value	ANOVA P Value	ANOVA P Value
Total no.	73	17	13	0.300	0.060	0.162
Range	0-8	0-2	0-2			
10-90%	0-2	0-1	0-1			
Mean	0.76	0.40	0.33			
SD	1.40	0.63	0.57			
Median	0	0	0			

[a] ANOVA=analysis of variance of mean numbers of disorders among differing use groups
[b] ANOVA=analysis of variance of mean log of numbers of disorders among differing use groups
[c] 10-90% = 10th to 90th percentiles
[d] SD = standard deviation

Table 9-Crude and Adjusted Number of Lower Extremity Musculoskeletal Disorders per Person During Five-Year Study According to Cigarette and Tobacco Use Status

Confounders	Cigarette Smoking Status			
	Never Mean ± SD[a]	Former Mean ± SD	Current Mean ± SD	ANOVA[b] P Value
Crude	0.74 ± 1.35	0.38 ± 0.61	0.30 ± 0.61	0.069
Age (years)	0.76 ± 1.12	0.42 ± 1.11	0.31 ± 1.12	0.092
Body Mass Index	0.75 ± 1.12	0.42 ± 1.11	0.31 ± 1.12	0.107
Drinks per Week	0.77 ± 1.13	0.41 ± 1.13	0.30 ± 1.13	0.088
Physical Activity[c]	0.75 ± 1.11	0.43 ± 1.11	0.33 ± 1.11	0.126
Multivariate	0.75 ± 1.14	0.42 ± 1.13	0.33 ± 1.14	0.139
Confounders	Tobacco Use Status			
	Never Mean ± SD	Former Mean ± SD	Current Mean ± SD	ANOVA P Value
Crude	0.76 ± 1.40	0.41 ± 0.63	0.33 ± 0.57	0.060
Age (years)	0.76 ± 1.11	0.40 ± 1.11	0.33 ± 1.11	0.061
Body Mass Index	0.76 ± 1.12	0.40 ± 1.11	0.32 ± 1.12	0.058
Drinks per Week	0.77 ± 1.13	0.40 ± 1.11	0.31 ± 1.14	0.060
Physical Activity	0.75 ± 1.11	0.44 ± 1.11	0.39 ± 1.11	0.170
Multivariate	0.76 ± 1.15	0.44 ± 1.13	0.38 ± 1.16	0.189

[a] SD = Standard Deviation.

[b] ANOVA = Analysis of Variance for crude means; analysis of covariance for adjusted means.

[c] Physical activity rating: 0=very inactive, 1=somewhat inactive, 3=average, 4=active, 5=very active.

Table 10-Crude and Adjusted Log of Number of Lower Extremity Musculoskeletal Disorders Per Person During Five-Year Study According to Cigarette and Tobacco Use Status

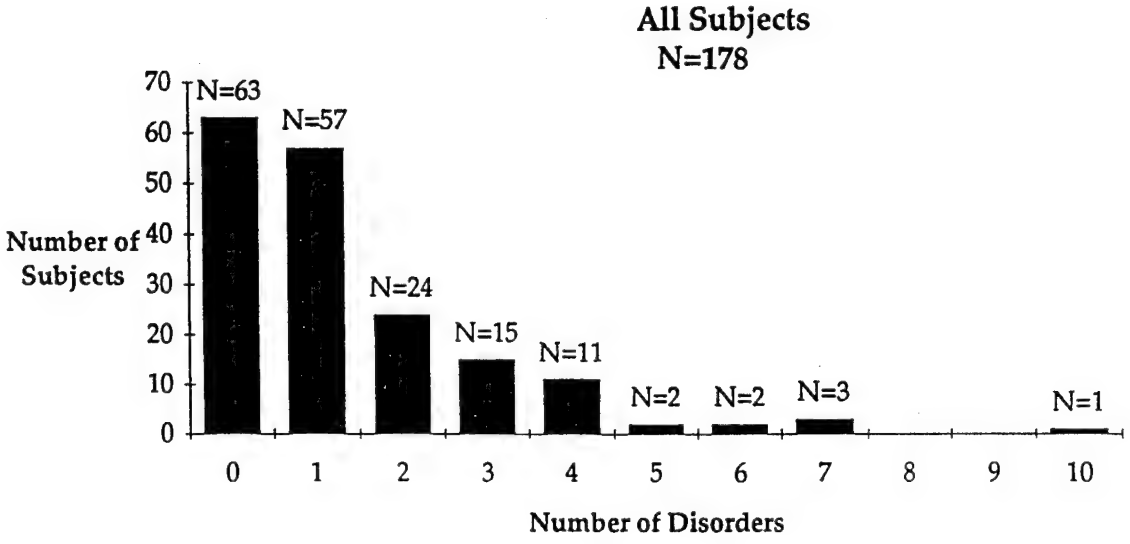
Confounders	Cigarette Smoking Status			ANOVA[b]
	Never Mean ± SD[a]	Former Mean ± SD	Current Mean ± SD	P Value
Crude	-0.06 ± 0.33	-0.14 ± 0.25	-0.18 ± 0.24	0.111
Age	-0.05 ± 0.29	-0.12 ± 0.30	-0.17 ± 0.30	0.141
Body Mass Index (kg/m^2)	-0.50 ± 0.30	-0.12 ± 0.30	-0.18 ± 0.30	0.130
Drinks per Week	-0.05 ± 0.33	-0.12 ± 0.30	-0.18 ± 0.30	0.113
Physical Activity[c]	-0.05 ± 0.30	-0.12 ± 0.30	-0.17 ± 0.30	0.179
Multivariate	-0.05 ± 0.29	-0.12 ± 0.31	-0.18 ± 0.31	0.145
Confounders	Tobacco Use Status			ANOVA
	Never Mean ± SD	Former Mean ± SD	Current Mean ± SD	P Value
Crude	-0.06 ± 0.34	-0.13 ± 0.26	-0.16 ± 0.24	0.162
Age	-0.05 ± 0.30	-0.11 ± 0.31	-0.14 ± 0.30	0.292
Body Mass Index (kg/m^2)	-0.05 ± 0.28	-0.11 ± 0.30	-0.14 ± 0.30	0.280
Drinks per Week	-0.05 ± 0.31	-0.12 ± 0.30	-0.15 ± 0.31	0.241
Physical Activity	-0.06 ± 0,30	-0.11 ± 0.30	-0..14 ± 0.30	0.390
Multivariate	-0.05 ± 0.31	-0.11 ± 0.31	-0.15 ± 0.32	0.341

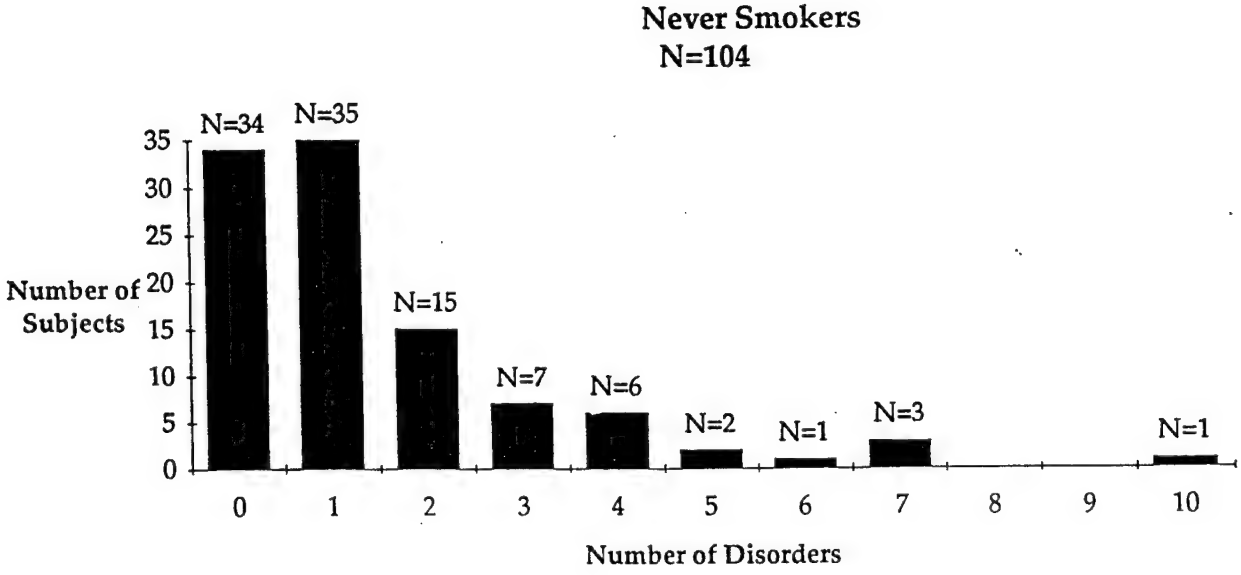
[a] SD = standard deviation

[b] ANOVA = analysis of variance for crude means; analysis of covariance for adjusted means

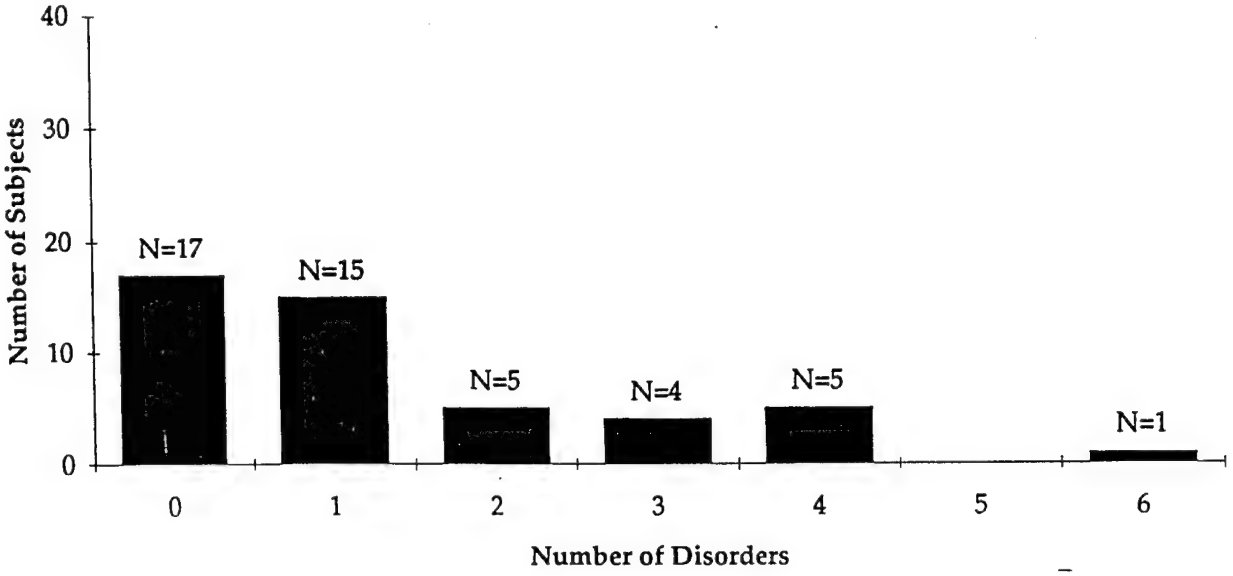
[c] Physical activity rating: 0=very inactive, 1=somewhat active, 2=average, 3=active, 4=vert active.

Figure 1-Frequency Distribution of Number of Musculoskeletal Disorders During Five-Year Study Period According to Cigarette Smoking Status

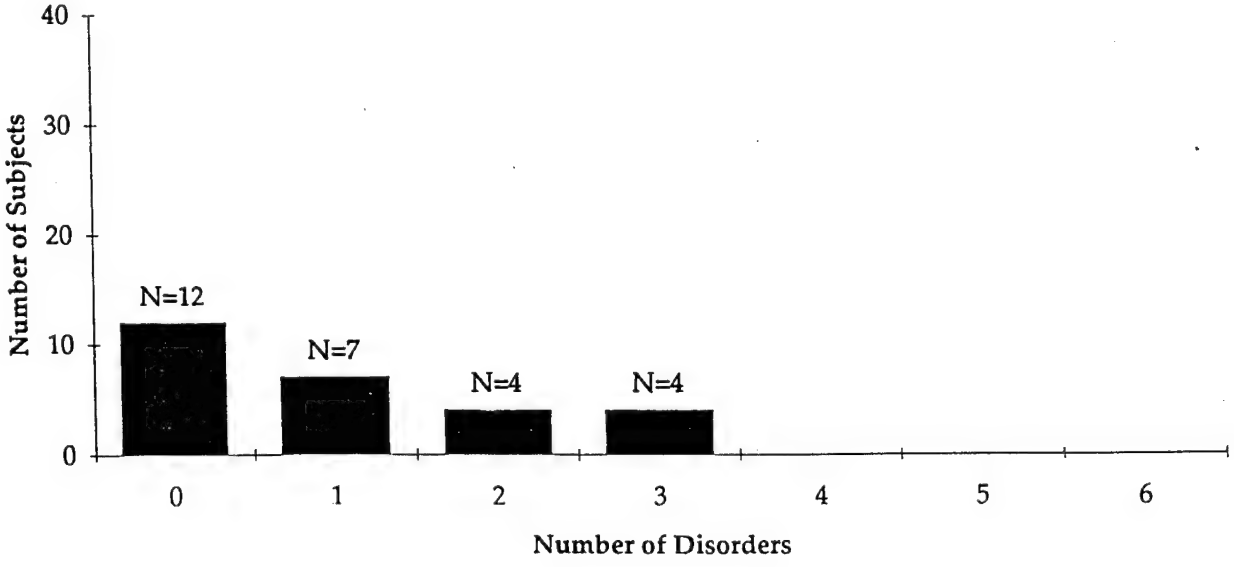




Former Smokers
N=47



Current Smokers
N=27



CONCLUSIONS

The results of two of the studies in this dissertation support a positive association between musculoskeletal disorders and current cigarette and tobacco use, which was stronger for lower extremity than for upper extremity disorders. Former users had a weaker association with musculoskeletal disorders as compared to current users. A dose-response effect was found for cigarette pack-year history and the number or cigarettes currently smoked per day with the prevalence of shoulder disorders. Potential confounders such as age, sex, body mass index, socioeconomic status, exposure to occupational stressors, recreational activity level, and alcohol consumption were considered in the designs or analyses, and were unlikely to account for the results.

The third study in the dissertation did not find a statistically significant association between cigarette and tobacco use and the rate of musculoskeletal disorders over a 5-year period. In fact, current smokers had the lowest rates of disorders. The misclassification of some potential confounders, and the loss of subjects who were more likely to have musculoskeletal disorders and be cigarette smokers may have influenced the results.

This dissertation contributes to the emerging body of

research which is exploring the relationship between musculoskeletal disorders and tobacco use. If such a relationship is true, it represents another important reason to avoid cigarette smoking and tobacco use. The subjects in this dissertation were employed, physically active, generally healthy middle aged men, along with a few women. Further research is needed to verify these findings in other populations, especially among young adults for whom the increased risk of musculoskeletal disorders in the near future may be a more persuasive anti-smoking message than the long term risks of lung cancer and cardiovascular disease. Causal mechanisms between cigarette and tobacco use and musculoskeletal disorders, while suggested in the dissertation, also need to be critically explored.

APPENDIX 1

Study 1

Main Questionnaire (all subjects) and Module B for Shoulder/Upper Arm Region

1. Year of birth: 19____
2. Sex: (1) ____ Male (2) ____ Female
3. Height: ____ ft ____ in
4. Weight: ____ lbs
5. a. Which hand do you write with? (1)___Right (2)___Left (3)___Either one
   b. Which hand do you use more at work?
   (1)___Right (2)___Left (3)___About the same

6. a. How many years have you worked at Chrysler? _____ yrs
   b. How many years have you worked at this plant? _____ yrs
7. a. What is your current job title? _____
   b. How long have you worked at this job? _____ mos _____ yrs

   If less than one year:

   c. What was your previous job title? _____
   d. How long did you work at that job? _____ mos _____ yrs
8. a. How many days (including today) have you worked since your last day off? ____
   b. How many hours have you worked, so far, today? _____ hours

   If overtime is not plant-wide:

   c. How many weeks have you worked more than 5 days in the past 12 months?
   _____ weeks
9. a. What type of work are you doing today? (please describe in detail)

   _____

   _____

   b. Is this a machine-paced job? (1) _____ yes (2) _____ no
   c. Is this your usual job? (1) _____ yes (2) _____ no
   d. If not: For how many days (including today) have you been doing this type of work? _____ days

"The next set of questions refers to your usual job." SHOW SUBJECT THE "BORG SCALE" TO PROMPT EACH ANSWER.

10. On a scale from 0 to 10, how would you rate the pace at which you usually work?

11. On a scale from 0 to 10, how would you rate the awkwardness of the back positions that you have to use? _____
12. On a scale from 0 to 10, how would you rate the awkwardness of the neck and shoulder positions that you have to use? _____
13. On a scale from 0 to 10, how would you rate the awkwardness of the arm positions that you have to use? _____
14. On a scale from 0 to 10, how would you rate the awkwardness of the wrist and hand positions that you have to use? _____
15. On a scale from 0 to 10, how would you rate the total physical effort required by your job? _____
16. On a scale from 0 to 10, how would you rate the amount of vibration that you feel through the floor while you're working? _____

Do you handle any parts by hand? (1) _____ yes (2) _____ no

If "No," skip to question #19.

17. On a scale from 0 to 10, how would you rate the weight of the most typical part (or the average weight) that you handle? _____
18. On a scale from 0 to 10, how would you rate the weight of the heaviest part that you handle? _____

Do you use any tools? (1) _____ yes (2) _____ no

If "No," skip to question #25. If "Yes:" "Please answer the next 6 questions for the tool that you use most frequently."

19. On a scale from 0 to 10, how would you rate the weight of the tool? _____
20. On a scale from 0 to 10, how would you rate the balance of the tool (meaning whether it stays balanced, or tends to tip or twist out of your hand)? _____
21. On a scale from 0 to 10, how would you rate the grip force required to hold and use the tool? _____
22. On a scale from 0 to 10, how would you rate the size of the tool handle? _____
23. On a scale from 0 to 10, how would you rate the pressure of the handle on the soft parts of your hand (for example, if edges rub or dig into your hand)? _____
24. On a scale from 0 to 10, how would you rate the amount of vibration that you feel through the tool handle? _____

25. Have you ever been told by a doctor that you had any of the following conditions?

a. Diabetes ("sugar")	(1)___Yes	(2)___No
b. Thyroid problem	(1)___Yes	(2)___No
c. Lupus (not skin lupus)	(1)___Yes	(2)___No
d. Gout	(1)___Yes	(2)___No
e. Kidney dialysis	(1)___Yes	(2)___No
f. Rheumatoid arthritis (diagnosed by blood test)	(1)___Yes	(2)___No
g. Mechanical problem in back, such as spondylitis or spondylolisthesis	(1)___Yes	(2)___No
h. Ankylosing spondylitis	(1)___Yes	(2)___No
i. Treatment for alcoholism	(1)___Yes	(2)___No

Women only:

j. Hysterectomy with removal of both ovaries	(0)___NA	(1)___Yes	(2)___No
k. Are you pregnant now?	(0)___NA	(1)___Yes	(2)___No

26. How would you describe your cigarette smoking habits?

(1) ____ Current smoker (2) ____ Former smoker (3) ____ Never smoked

27. If current smoker:

a. What is the average number of cigarettes that you smoke per day? (one pack = 20 cigarettes) _____ cigarettes per day

b. How many years have you smoked? _____ years

28. If former smoker:

a. How many years has it been since you smoked cigarettes regularly? _____ yrs

b. How many years did you smoke cigarettes before quitting? _____ yrs

c. What was the average number of cigarettes you smoked per day during the 2 years before you quit? _____ cigarettes per day

29. How would you describe your use of other tobacco products, such as cigars, pipes, or smokeless tobacco (chewing tobacco, snuff, pouches, etc.)?

(1) ____ Current user (2) ____ Former user (3) ____ Never used

30. How would you describe your consumption of alcohol-containing beverages (beer, wine, etc)?

(1) ____ Currently drink (2) ____ Formerly drank (3) ____ Never drank

31. If current drinker:

What is the average number of drinks that you have in a typical week?

(one beer, glass of wine, or shot of liquor = 1 drink; 1 quart of beer = 3 drinks; 1/2 pint of liquor = 5 drinks; 1 pint of liquor = 10 drinks)

_____ drinks per week

32. If current or former drinker:

a. In the past 3 years, did you drink more heavily than you do now?

(1)___Yes (2)___No

b. If "Yes:" For how many years? _____ years

c. How many drinks did you average per week, during this heavier drinking period?

(one beer, glass of wine, or shot of liquor = 1 drink; 1 quart of beer = 3 drinks; 1/2 pint of liquor = 5 drinks; 1 pint of liquor = 10 drinks)

_____ drinks per week

33. How often do you do at least 20 minutes of vigorous activity that greatly increases your breathing and works up a sweat (like fast walking, jogging, bicycling, swimming, rowing, etc.)?

(1) ____ rarely or never
(2) ____ 2-3 times a month
(3) ____ 1-2 times a week
(4) ____ 3 or more times a week

34. How many city blocks or their equivalent do you walk regularly each day?

(1 mile = 12 blocks) _____ blocks

35. How many flights of stairs do you climb up each day? (10 steps = 1 flight)

_____ flights

36. Are there any hobbies, sports activities, second jobs, or other activities that you do every week? (including housework) (1)___Yes (2)___No

If "Yes:" What are those activities? How many hours a week, on average?

a. _____ _____ hours per week
b. _____ _____ hours per week
c. _____ _____ hours per week
d. _____ _____ hours per week
e. _____ _____ hours per week

37. Has a doctor or chiropractor ever told you that you have any of the following conditions affecting your back, neck, arms or legs?

a. Ruptured ("slipped") disc in neck (1)___Yes (2)___No
b. Ruptured ("slipped") disc in back (1)___Yes (2)___No
c. Carpal tunnel syndrome (1)___Yes (2)___No
   If "Yes:" On which side? (1)___Right (2)___Left (3)___Both
d. Raynaud's disease ("vibration white finger") (1)___Yes (2)___No
   If "Yes:" On which side? (1)___Right (2)___Left (3)___Both
e. Thoracic outlet syndrome (1)___Yes (2)___No
   If "Yes:" On which side? (1)___Right (2)___Left (3)___Both

38. Have you ever had any injuries to your fingers, hands, wrists, elbows, shoulders, neck or back? (This includes fracture, dislocation, sports injury, industrial accident, frostbite, automobile accident, etc., that was treated by a doctor or chiropractor).

(1)___Yes (2)___No

If "Yes:" Please tell me all of the injuries that you have had.

	TYPE (eg., break, cut, sprain)	LOCATION (eg., left elbow, neck)	YEAR
a.	_____	_____	_____
b.	_____	_____	_____
c.	_____	_____	_____
d.	_____	_____	_____
e.	_____	_____	_____

39. Are there any other serious joint, nerve, muscle or tendon problems that you haven't told me about already? (1)___Yes (2)___No

If "Yes": Please tell me all of the joint, nerve, muscle, and tendon problems that you have had (arthritis, tendinitis, bursitis, ganglion, etc.).
[ASK: type, location, and whether still an active problem (symptoms, function, etc.).]

	TYPE (eg., tendinitis, ganglion)	LOCATION (eg., left elbow, neck)	ACTIVE*
a.	_____	_____	_____
b.	_____	_____	_____
c.	_____	_____	_____
d.	_____	_____	_____
e.	_____	_____	_____

* 1=Yes, 2=No

40. Are you currently taking any type of medication on a regular basis? This would include all prescription medicines and any over-the-counter medicine that you take every day. [LIST type or name. For women: ask specifically about birth control pills and ERT (eg., Premarin).]

0) _____ None

Yes: a. _____
b. _____
c. _____
d. _____
e. _____

** In the following question, by "discomfort," we mean any type of pain, cramping, burning, stiffness, aching, soreness, tingling ("pins and needles"), or numbness **

41. During the past 12 months, have you had pain, aching, stiffness, burning, numbness, or tingling ("pins and needles") - in any of the areas shown on these diagrams - <u>that occurred more than three times OR lasted more than one week</u>?
(REFER TO DIAGRAM ON SEPARATE PAGE TO CODE PAIN LOCATION.)

			Include Module:
a.	Low back:	(1)___Yes (2)___No	
b.	Middle or upper back:	(1)___Yes (2)___No	
c.	Neck:	(1)___Yes (2)___No	A
d.	Shoulder or upper arm:	(1)___Yes (2)___No	B
e.	Elbow or forearm:	(1)___Yes (2)___No	C
f.	Wrist or hand:	(1)___Yes (2)___No	D
g.	Knee:	(1)___Yes (2)___No	

<u>If "Yes" to any body part:</u> **Select additional questionnaire modules to include, based on worker's answers to this question.**

<u>If "No" to all body parts:</u> "Thank you very much for your time and assistance." <u>(STOP INTERVIEW HERE.)</u>

MODULE B: SHOULDER/UPPER ARM PAIN ID # _____

"I'd like to ask you some specific questions about your SHOULDER or ARM discomfort."

1. Which side of your body is most affected?

   (1) ___ Right (2)___ Left (3)___ Both

2. How often do you have numbness or tingling in your arms or hands?

   (1) ___ Never
   (2) ___ Occasionally
   (3) ___ Only with certain motions
   (4) ___ More than once a week
   (5) ___ More than once per day

3. Did the problem start:

   (1) ___ Suddenly (2) ___ Gradually (3) ___ Do not know

4. When did you first notice shoulder/arm pain or discomfort? ___/___ (month/year)

5. What specific job were you working at that time (when the problem first started)?

   _____

   _____

6. What seemed to cause the problem? [Read choices "a," "b," and "c." Select the answer that comes closest.]

   a. Acute injury: (1) ____ at home (Describe: _____)
   (2) ____ at work (Describe: _____)

   b. Sudden motion: (3) ____ at home (Describe: _____)
   (4) ____ at work (Describe: _____)

   c. Repetitive activity: (5) ____ at home (Describe: _____)
   (6) ____ at work (Describe: _____)

   d. Other (7) ____ (Describe:_____)

   e. Don't know (9) ____

7. a. Do you have this discomfort now? (1) ___ Yes (2) ___ No

   b. <u>if "No:"</u> When did you last experience this problem? ___/___/___ (mo/day/yr)

   c. What do you think caused it to stop?_____

8. Please make a mark on the line below to show how bad your pain is AT THIS MOMENT.

   unbearable pain _____ no pain

9. Please make a mark on the line below to show how bad your pain has been DURING THE PAST 7 DAYS.

   unbearable pain _____ no pain

10. Please make a mark on the line below to show how bad your pain has been DURING THE WORST EPISODE IN THE PAST YEAR (12 MONTHS).

unbearable pain _____ no pain

11. How often have you had this problem in the past 12 months?

_____ times this year

_____ continuous for the past year (=> SKIP THE NEXT QUESTION)

12. How long does the discomfort usually last?

(1) ___ Less than one hour (4) ___ Less than one month

(2) ___ Less than one day (5) ___ Less than 6 months

(3) ___ Less than one week (6) ___ More than six months

13. When you are away from work for more than a week does the problem:

(1) ___ Increase (3) ___ Not change

(2) ___ Decrease (4) ___ Don't know

14. In the last 12 months, how many days did you stay off work because of this problem?

_____ days off

15. In the last 12 months, how many days were you on restricted work because of this problem?

_____ days restricted

16. In the last 12 months, have you requested a change to a different job because of this problem?

(1) ___ Yes (2) ___ No

17. Have you ever stopped or decreased any other activities (such as sports, hobbies, or housework) since this problem started?

(1) ___ Yes (2) ___ No

If "Yes:" What activities? _____

_____

In what year? 19 _____

18. In the following list of activities, please tell me the number on a scale from 1 to 5 that best describes how much difficulty you had with each activity because of your shoulder or upper arm problem, on a typical day in the past two weeks.

	NO PAIN OR DIFFICULTY				IMPOSSIBLE
a. turning head to either side	1	2	3	4	5
b. reaching up to comb your hair	1	2	3	4	5
c. scratching or washing your back	1	2	3	4	5
d. falling asleep	1	2	3	4	5
e. placing an object on a high shelf	1	2	3	4	5
f. driving a car for over 30 miles	1	2	3	4	5
g. putting on a shirt or blouse	1	2	3	4	5
h. lifting or carrying a heavy object of 10 pounds	1	2	3	4	5
i. pushing a lawn mower	1	2	3	4	5
j. performing your current job	1	2	3	4	5

19. Which of the following types of medical care, if any, have you seen for this problem in the past 12 months?

Plant medical department	(1) ___ Yes	(2) ___ No
Outside the plant:		
a. ___ family doctor/general practioner	(1) ___ Yes	(2) ___ No
b. ___ chiropractor	(1) ___ Yes	(2) ___ No
c. ___ occupational physician/clinic	(1) ___ Yes	(2) ___ No
d. ___ specialist (eg,orthopedist,neurologist)	(1) ___ Yes	(2) ___ No
e. ___ physical therapist	(1) ___ Yes	(2) ___ No
f. ___ surgeon (surgery performed)	(1) ___ Yes	(2) ___ No
g. ___ other	(1) ___ Yes	(2) ___ No

APPENDIX 2

Study 1

Protocol for Physical Examination of Shoulder/Upper Arm Region

SCREENING PHYSICAL EXAMINATION FOR UPPER EXTREMITY CUMULATIVE TRAUMA DISORDERS

The examination protocol includes inspection, range of motion (ROM) testing and specialized tests for specific syndromes.

Range of Motion

1. Active ROM indicates that:

   a. The patient is willing and able to perform the action.

   b. Range of motion is possible.

   c. Enough muscle power is present to perform the action.

   d. A painful arc occurring at mid range only implies that the tender structure is pinched between two bony surfaces.

=> IF there is pain or limitation on active ROM, passive ROM should be performed. Otherwise, skip the passive maneuver.

2. Passive ROM indicates the state of the inert tissue or the joint itself.

   a. It is extremely important that the patient does not assist in these maneuvers or one is actually performing active ROM.

   b. Pain at the extremes of passive ROM may be the result of muscle/tendon stretch. This should not be considered as a joint problem.

3. Resisted isometric muscle test indicates the state of muscle/tendon groups about the joint.

   a. The joint is held at mid range or in a neutral position.

   b. All articular or joint movement is prevented by the examiner, using counter-balancing force.

   c. The only tension that alters is within the muscles and loading of the tendons. Therefore, in arthritic or other joint problems, resisted ROMs would be relatively painless.

   d. Strength as well as pain can be assessed.

PHYSICAL EXAMINATION (continued)

Coding Instructions

Inspection:

1 = ganglion or nodule
2 = bony swelling (as in degenerative joint disease)
3 = soft swelling
4 = redness
5 = tenderness
6 = deformity
7 = significant scar
8 = muscle wasting
9 = any other abnormality

N = Normal

0 = normal
1 = pain or limited ROM

=> If ACTIVE motion gives no pain & normal ROM, skip PASSIVE maneuver.

P = Pain

0 = none at all
1 = slight
2
|
7
8 = most extreme imaginable

ROM = Range of Motion

3 = normal	(0 - 10% limitation)
2 = slightly limited	(11% - 33% limitation)
1 = moderately limited	(34% - 66% limitation)
0 = severely limited	(67%-100% limitation)

ST = Strength

5 = normal
4 = good
3 = fair
2 = poor
1 = minimal contraction
0 = no contraction

PHYSICAL EXAMINATION (continued)

Coding Instructions (continued)

Specialized Tests:

Adson's test (for thoracic outlet syndrome)

Elevation and external rotation of the arm; extension of the neck; head turned toward arm; subject takes deep breath and holds it.

Pul = obliteration of arterial pulse
NT = numbness and/or tingling in the hand
N = normal otherwise

Finkelstein's test (for deQuervain's disease: tendinitis of thumb extensors)

Passive ulnar deviation of the wrist, with fingers held inside the fist.

P = pain in thumb extensor tendons
N = normal otherwise

Phalen's test (for carpal tunnel syndrome)

Passive wrist flexion (backs of hands lightly pressed together) for 60 seconds.

P = pain
NT = numbness and/or tingling

-> either symptom located in at least 2 of digits 1, 2, or 3;
symptoms also allowed in palm (medial aspect), wrist, proximal to wrist, or 5th finger

N = normal otherwise

PHYSICAL EXAMINATION (continued)

Joint Status Summary: Indicate all that apply

Normal = No pain or loss of ROM on active motion.
No pain; normal or good strength on resisted motion

Muscle/Tendon = Increased pain on resisted motion, with or without weakness

Joint = Decreased ROM on passive motion, with or without pain

Nerve = Radiating pain or tingling along course of nerve
Decreased sensation
Weakness on resisted motion, without increased pain

SHOULDER		Left		Right	
Inspection:		1 2 3 4 5 6 7 8 9		1 2 3 4 5 6 7 8 9	
Comments:					
Abduction (180°)	Actv:	N	P=____ ROM=____	N	P=____ ROM=____
	*Pass:	N	P=____ ROM=____	N	P=____ ROM=____
Flexion (180°)	Actv:	N	P=____ ROM=____	N	P=____ ROM=____
	*Pass:	N	P=____ ROM=____	N	P=____ ROM=____
Ext Rotation (90°)	Actv:	N	P=____ ROM=____	N	P=____ ROM=____
	*Pass:	N	P=____ ROM=____	N	P=____ ROM=____
Abduction	Rest:	N	P=____ ST=____	N	P=____ ST=____
Lateral Rotation	Rest:	N	P=____ ST=____	N	P=____ ST=____
Medial Rotation	Rest:	N	P=____ ST=____	N	P=____ ST=____
Adson's Test * obliteration of pulse (thoracic outlet syndrome)		N	Pul* NT=____	N	Pul* NT=____
Joint Summary:		N	Ms/Tn Jt Nrv/Vasc	N	Ms/Tn Jt Nrv/Vasc

APPENDIX 3

Study 1

Construction of Exposure Scores from Psychophysical Measures

Construction of Exposure Scores from Psychophysical Measures

Factor	Psychophysical Measure (range 0 - 10)				Used in which score(s)*
	0	0 < x ≤ 3.33	3.33 < x ≤ 6.67	6.67 < x ≤10	
1. Work Pace	0	1	2	3	UE, SH, WH
2.a. Grip force	0	1	2	3	UE, SH, WH
2.b. Whole body effort	0	1	2	3	UE, SH
3.a. Neck and shoulder postures	0	1	2	3	UE, SH, WH
3.b. Arm postures	0	1	2	3	UE, SH, WH
3.c. Wrist/hand postures	0	1	2	3	UE, SH, WH
4. Contact stress from tool handle	0	1	2	3	UE, WH
5. a. Segmental vibration	0	1	2	3	UE, SH, WH
5.b. Whole body vibration	0	1	2	3	UE, SH
7. Machine-paced work	No = 0			Yes = 1	UE, SH, WH

UE = Upper extremity exposure score — Maximum possible score = 28
SH = Shoulder exposure score (used only for shoulder/upper arm disorders) — Maximum possible score = 25
WH = Wrist/hand exposure score (used only for wrist/hand disorders) — Maximum possible score = 22

APPENDIX 4

Study 1

Leisure Time Activity Level

SPORTS

Low energy expenditure category

Bowling	3.0 Kcal/kg/hr
Calisthenics	4.5
Fishing & Hunting	4.0
Golf	4.5
Horseback riding	4.0
Racing (cars)	4.0
Mean= 4.0	Median=4.0

Moderate energy expenditure category

Baseball/Softball	5.0 Kcal/kg/hr
Dancing	4.5
Health Spa Activity	4.5
Housework	2.5
Roller skating	7.0
Skiing	6.0
Volleyball	3.0
Walking	3.5
Weight lifting	6.0
Mean=4.7	Median=4.5

High energy expenditure category

Aerobic exercise	5.5 Kcal/kg/hr
Basketball	6.0
Boxing	6.0
Football	8.0
Hockey	8.0
Jog/run	7.0
Racquet sports	5.0
Riding bicycle	5.0
Soccer	7.0
Swimming	8.0
Tennis	7.0
Mean=6.8	Median=7.0

HOBBIES

Very low energy expenditure category

Antique car restoring	3.0 Kcal/kg/hr
Billiards	2.5
Board games	1.5
Card playing	1.5

Church/clubs	1.5
Coaching sports	4.0
Collector (coins)	1.3
Computers	1.8
Drawing	1.5
Drums	4.0
Guitar/piano	2.5
Horseshoes	3.0
Model building	1.5
Motorcycle riding	2.5
Music/singing	2.5
Photography/artistry	1.8
Playing with children	3.0
Reading/movies	1.3
Repairs around house	3.0
Sewing/crocheting	1.5
Training dogs	not available

Mean=2.3 Median=2.5

Moderate energy expenditure category

Carpentry	4.5 Kcal/kg/hr
Gardening/Landscaping	5.0

Mean=4.7

SECOND JOBS

Very low energy expenditure category	2.3 Kcal/kg/hr
Moderate energy expenditure category	4.7
Unspecified	2.3

Means and Standard Deviations of Hours per Week Spent in Each Energy Expenditure Category

SPORTS			
Low energy expenditure (n=298)	mean=6.8	sd=6.7	median=4.5
Moderate (n=298)	mean=5.7	sd=5.7	median=4.0
High (n=231)	mean=4.6	sd=4.0	median=4.0
HOBBIES			
Very low energy expenditure (n=274)	mean=9.9	sd=9.0	median=7.0
Moderate (n=82)	mean=7.6	sd=7.4	median=6.0
SECOND JOBS			
Very low energy expenditure (n=5)	mean=11.2	sd=7.8	median=14.0
Moderate (n=2)	mean=32.5	sd=24.8	median=32.5
Unspecified (n=26)	mean=11.8	sd=10.0	median=10.0

Appendix 5 -Odds Ratios for Shoulder Disorder Determined by Questionnaire According to Cigarette Smoking Status, Within Strata for Potential Confounders.

Potential Confounders	Never Smokers		Former Smokers		Current Smokers	
	Cases/n	OR	Cases/n	OR	Cases/n	OR
Gender						
Male	34/322	1.0	32/221	1.43	81/511	1.60
Female	18/86	1.0	7/34	0.98	31/117	1.36
Age (yrs)						
≤ 41	9/121	1.0	6/45	1.92	30/174	2.59
42-46	19/107	1.0	4/53	0.38	25/162	0.85
47-52	14/89	1.0	13/81	1.02	29/158	1.20
> 52	10/91	1.0	16/76	2.16	28/134	2.14
Body Mass Index (kg/m^2)						
≤ 24.0	10/74	1.0	8/37	1.77	31/209	1.12
24.1-26.6	12/96	1.0	9/68	1.07	25/160	1.30
26.7-30.0	12/112	1.0	12/69	1.75	26/144	1.84
> 30.0	18/124	1.0	10/81	0.83	30/115	2.08
Disease						
Yes	14/57	1.0	9/43	0.81	24/92	1.08
No	38/350	1.0	30/212	1.35	88/536	1.61
Prior Trauma						
Yes	2/5	1.0	2/3	3.00	4/11	0.86
No	50/408	1.0	37/252	1.22	108/617	1.50
Plant						
Stamping	29/243	1.0	13/115	0.94	56/319	1.57
Engine	23/165	1.0	26/140	1.41	56/309	1.37

Appendix 5 -Continued

UE Work Exposure						
0-6	7/82	1.0	3/59	0.57	10/116	1.01
7-12	14/123	1.0	11/69	1.48	25/181	1.25
13-18	22/155	1.0	22/108	1.55	58/255	1.78
19-25	9/48	1.0	3/19	0.81	19/73	1.53
Drinks per Week						
0	31/229	1.0	12/118	0.72	47/254	1.45
>0-2	11/76	1.0	7/60	0,78	29/123	1.82
3-7	4/68	1.0	9/44	4.11	16/125	2.35
>7	6/35	1.0	11/31	2.66	18/124	0.82
Leisure Activity (Kcal/kg)						
0	19/154	1.0	13/106	0.99	48/228	1.90
>0-18.4	9/77	1.0	10/54	1.72	18/128	1.24
18.5-47.0	13/97	1.0	12/52	1.94	23/130	1.39
>47.0	11/80	1.0	4/43	0.64	23/142	1.21
Years at Chrysler						
0-19.0	12/110	1.0	4/40	0.91	26/155	1.65
19.1-21.0	17/102	1.0	7/44	0.95	26/147	1.07
21.1-25.0	14/109	1.0	15/78	1.62	34/172	1.67
>25.0	9/86	1.0	13/93	1.40	26/154	1.74
Years at Job						
0-4.0	12/106	1.0	7/60	1.04	28/173	1.51
4.1-10.0	11/95	1.0	11/69	1.45	26/166	1.42
10.1-18.0	15/150	1.0	10/57	1.21	31/149	1.49
>18.0	14/107	1.0	11/69	1.26	27/140	1.59

Appendix 6 -Evaluation of an Additive Interaction Between Shoulder Disorder Determined by Questionnaire and Drinks per Week.

	Odds Ratio	
Smoking Status	≤2 Drinks	>2 Drinks
Never	1.0	0.8
Former	0.7	2.7
Current	1.6	1.2

	AP (AB)[a]	RERI (AB)[b]	Synergy Index[c]
Former vs Never	0.81	2.2	-3.4
Current vs Never	-0.17	-0.2	0.5

[a] Attributable Proportion = $\frac{OR(AB)-OR(A\bar{B})-OR(\bar{A}B)+1}{OR(AB)}$

[b] Relative Excess Risk due to Interaction = $OR(AB)-OR(A\bar{B})-OR(\bar{A}B)+1$

[c] Synergy Index = $\frac{OR(AB)-1}{OR(A\bar{B})+OR(\bar{A}B)-2}$

Appendix 7-Odds Ratios for Shoulder Disorder Determined by Questionnaire According to Tobacco Use, Status, Within Strata for Potential Confounders.

Potential Confounders	Never Users		Former Users		Current Users	
	Cases/n	OR	Cases/n	OR	Cases/n	OR
Gender						
Male	27/268	1.0	31/227	1.41	89/559	1.69
Female	18/85	1.0	7/35	0.93	31/117	1.34
Age (yrs)						
≤ 41	8/113	1.0	4/44	1.31	33/183	2.89
42-46	15/91	1.0	5/55	0.51	28/176	0.96
47-52	14/76	1.0	12/85	0.73	30/167	0.97
> 52	8/73	1.0	17/73	2.26	29/150	1.95
Body Mass Index (kg/m^2)						
≤ 24.0	9/67	1.0	8/38	1.99	32/215	1.23
24.1-26.6	11/87	1.0	9/69	1.04	26/168	1.27
26.7-30.0	10/93	1.0	10/68	1.43	30/164	1.86
> 30.0	15/104	1.0	11/87	0.86	32/129	1.96
Disease						
Yes	13/51	1.0	9/45	0.73	25/96	1.03
No	32/301	1.0	29/217	1.30	95/580	1.65
Prior Trauma						
Yes	2/4	1.0	2/3	2.00	4/12	0.50
No	43/349	1.0	36/259	1.15	116/664	1.50
Plant						
Stamping	28/216	1.0	13/121	0.81	57/340	1.35
Engine	17/137	1.0	25/141	1.52	63/336	1.63

Appendix 7-Continued

UE Work Exposure						
0-6	6/71	1.0	3/57	0.60	11/129	1.01
7-12	13/106	1.0	10/72	1.15	27/195	1.25
13-18	18/134	1.0	21/112	1.49	63/272	1.78
19-25	8/42	1.0	4/21	1.00	19/77	1.53
Drinks per Week						
0	28/211	1.0	14/124	0.83	48/266	1.45
>0-2	10/67	1.0	7/59	0.77	30/133	1.82
3-7	3/47	1.0	9/47	3.47	17/143	2.35
>7	4/28	1.0	8/30	2.18	23/132	0.82
Leisure Activity (Kcal/kg)						
0	17/134	1.0	13/106	0.96	50/248	1.74
>0-18.4	7/69	1.0	10/51	2.16	20/139	1.49
18.5-47.0	10/81	1.0	12/58	1.85	26/140	1.62
>47.0	11/69	1.0	3/47	0.36	24/149	1.01
Years at Chrysler						
0-19.0	12/104	1.0	4/38	0.90	26/163	1.45
19.1-21.0	15/96	1.0	5/43	0.71	30/154	1.31
21.1-25.0	12/87	1.0	16/82	1.50	35/190	1.41
>25.0	6/65	1.0	13/99	1.49	29/169	2.04
Years at Job						
0-4.0	10/94	1.0	6/62	0.90	31/183	1.71
4.1-10.0	8/79	1.0	11/70	1.65	29/152	1.69
10.1-18.0	15/89	1.0	9/55	0.97	32/162	1.21
>18.0	12/91	1.0	12/75	1.25	28/150	1.51

Appendix 8-Odds Ratios for Shoulder Disorder Determined by Questionnaire According to Tobacco Use, Status, Within Strata for Potential Confounders.

Potential Confounders	Never Smokers		Former Smokers		Current Smokers	
	Cases/n	OR	Cases/n	OR	Cases/n	OR
Gender						
Male	84/318	1.0	75/220	1.44	190/509	1.66
Female	43/86	1.0	43/86	1.13	64/117	1.21
Age (yrs)						
≤ 41	25/121	1.0	15/45	1.92	71/173	2.67
42-46	38/107	1.0	22/53	1.29	70/162	1.38
47-52	27/86	1.0	30/81	1.29	57/157	1.25
> 52	37/90	1.0	26/75	0.76	56/134	1.03
Body Mass Index (kg/m^2)						
≤ 24.0	21/74	1.0	17/37	2.15	81/208	1.61
24.1-26.6	25/95	1.0	17/68	0.93	56/159	1.52
26.7-30.0	37/110	1.0	29/68	1.47	61/83	1.45
> 30.0	44/123	1.0	30/81	1.06	56/115	1.70
Disease						
Yes	29/56	1.0	21/43	0.89	45/92	0.89
No	98/347	1.0	72/211	1.32	209/534	1.63
Prior Trauma						
Yes	3/4	1.0	3/3	1.32	9/11	1.50
No	124/400	1.0	90/251	1.24	245/615	1.47
Plant						
Stamping	77/242	1.0	31/115	0.79	123/319	1.35
Engine	50/162	1.0	62/139	1.80	131/307	1.67

Appendix 8-Continued

UE Work Exposure						
0-6	18/82	1.0	18/59	1.56	33/115	1.43
7-12	38/121	1.0	27/69	1.40	66/181	1.25
13-18	52/153	1.0	42/108	1.24	114/254	1.58
19-25	19/48	1.0	6/18	0.76	38/73	1.66
Drinks per Week						
0	78/226	1.0	39/118	0.94	97/253	1.18
>0-2	25/75	1.0	29/59	1.93	59/64	1.84
3-7	15/68	1.0	12/44	1.33	46/125	2.06
>7	9/35	1.0	13/31	2.09	50/123	1.98
Leisure Activity (Kcal/kg)						
0	44/152	1.0	31/105	1.03	92/227	1.67
>0-18.4	31/75	1.0	26/54	1.32	52/127	0.98
18.5-47.0	25/97	1.0	20/52	1.80	52/131	1.90
>47.0	27/80	1.0	16/43	1.16	58/141	1.37
Years at Chrysler						
0-19.0	30/110	1.0	10/40	0.89	61/155	1.73
19.1-21.0	37/101	1.0	15/44	0.90	73/147	1.71
21.1-25.0	34/107	1.0	29/77	1.30	64/170	1.30
>25.0	26/85	1.0	39/93	1.64	56/154	1.30
Years at Job						
0-4.0	27/105	1.0	23/60	1.80	65/171	1.77
4.1-10.0	33/95	1.0	25/69	1.07	68/98	1.30
10.1-18.0	33/100	1.0	18/57	0.94	64/149	1.53
>18.0	34/104	1.0	27/68	1.36	57/140	1.41

Appendix 9 -Odds Ratios for Shoulder Disorder Determined by Questionnaire According to Tobacco Use, Status, Within Strata for Potential Confounders.

Potential Confounders	Never Users		Former Users		Current Users	
	Cases/n	OR	Cases/n	OR	Cases/n	OR
Gender						
Male	70/264	1.0	68/226	1.19	211/557	1.69
Female	43/85	1.0	18/35	1.03	64/117	1.18
Age (yrs)						
≤ 41	24/113	1.0	13/44	1.56	74/182	2.54
42-46	32/91	1.0	22/55	1.23	76/176	1.40
47-52	26/73	1.0	27/85	0.84	61/166	1.05
> 52	31/72	1.0	24/77	0.60	64/150	0.98
Body Mass Index (kg/m^2)						
≤ 24.0	19/67	1.0	17/38	2.05	83/214	1.60
24.1-26.6	22/86	1.0	17/69	0.95	59/167	1.59
26.7-30.0	32/91	1.0	24/67	1.03	71/164	1.41
> 30.0	40/103	1.0	28/87	0.75	62/129	1.46
Disease						
Yes	27/50	1.0	20/45	0.68	48/96	0.85
No	86/298	1.0	66/216	1.09	227/578	1.59
Prior Trauma						
Yes	2/3	1.0	3/3	1.50	10/12	2.50
No	11/235	1.0	83/258	1.00	265/662	1.41
Plant						
Stamping	73/215	1.0	30/121	0.64	128/340	1.17
Engine	40/134	1.0	56/140	1.57	147/334	1.85

Appendix 9- Continued

UE Work Exposure						
0-6	15/71	1.0	16/57	1.46	38/128	1.58
7-12	33/104	1.0	25/72	1.14	73/195	1.29
13-18	47/132	1.0	39/112	0.97	122/271	1.48
19-25	18/42	1.0	6/20	0.57	39/77	1.37
Drinks per Week						
0	72/208	1.0	38/124	0.84	104/265	1.22
>0-2	21/66	1.0	27/58	1.87	65/133	2.05
3-7	13/47	1.0	11/47	0.80	49/143	1.36
>7	7/28	1.0	10/30	1.50	55/131	2.17
Leisure Activity (Kcal/kg)						
0	40/132	1.0	30/105	0.92	97/247	1.49
>0-18.4	26/67	1.0	23/51	1.30	60/138	1.21
18.5-47.0	22/81	1.0	19/58	1.31	56/141	1.77
>47.0	25/69	1.0	14/47	0.75	62/148	1.27
Years at Chrysler						
0-19.0	29/104	1.0	10/38	0.92	62/163	1.59
19.1-21.0	35/95	1.0	13/43	0.74	77/154	1.71
21.1-25.0	29/85	1.0	26/81	0.91	72/188	1.20
>25.0	20/64	1.0	37/99	1.31	64/169	1.34
Years at Job						
0-4.0	24/93	1.0	20/62	1.37	71/181	1.86
4.1-10.0	28/79	1.0	23/70	0.89	75/181	1.29
10.1-18.0	32/89	1.0	17/55	0.80	66/162	1.23
>18.0	29/88	1.0	26/74	1.10	63/150	1.47

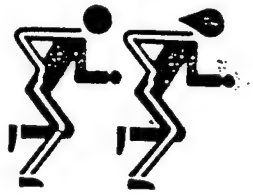
APPENDIX 10

Studies 2 and 3

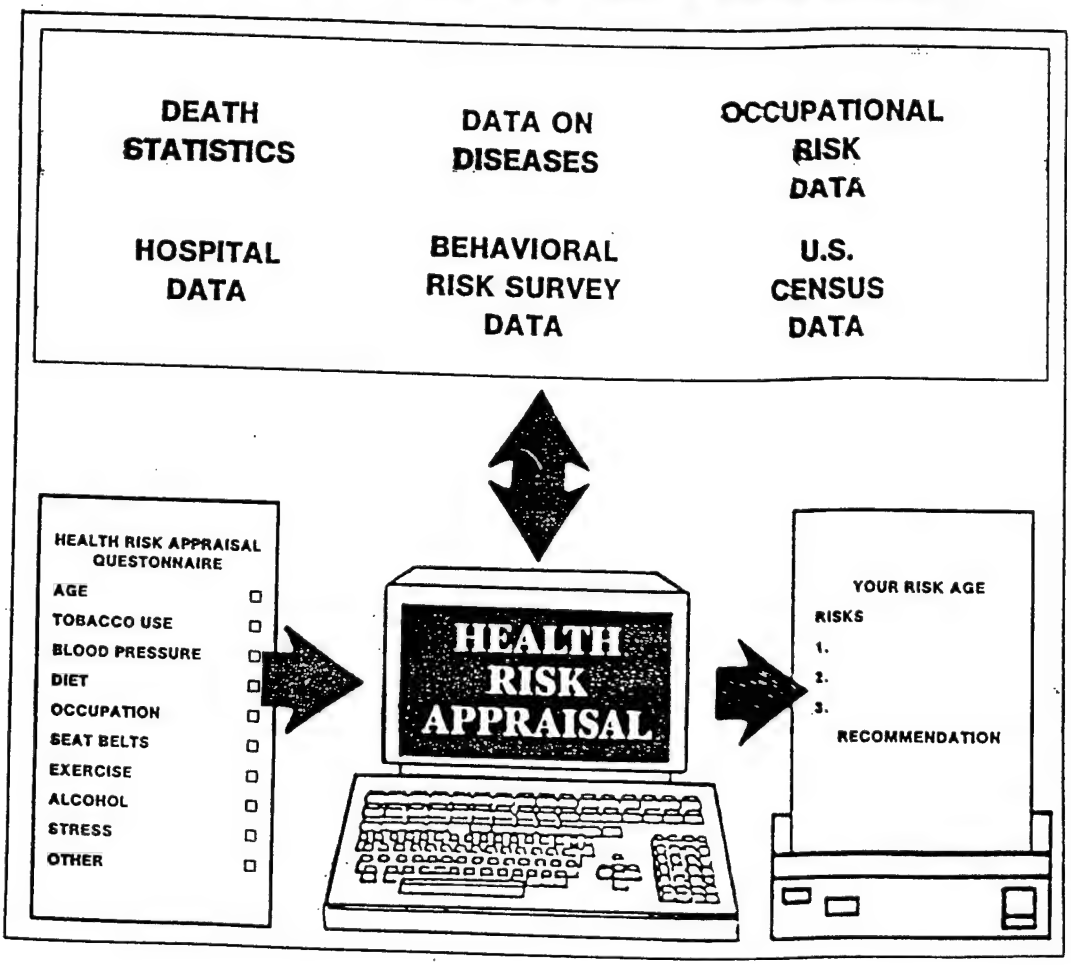
Health Risk Appraisal

THE ARMY HEALTH PROMOTION PROGRAM

Fit to Win



HEALTH RISK APPRAISAL



HSC Form 592 (TEST) (HSHS-SM) 1 Aug 89

The HEALTH RISK APPRAISAL is an activity of

THE ARMY HEALTH PROMOTION PROGRAM

How does the Health Risk Appraisal work?

The health risk appraisal is a personalized estimation of your risks of death and major illness in the next ten years. First, the program uses your age and health-related personal habits, as well as national statistics on risk factors and diseases, to calculate your current risks.

Your risk may be expressed in terms of RISK AGE or HEALTH SCORE. Ideally, you want a risk age lower than your real age or a health score of 100 points.

The second part of your health risk appraisal calculates your risks again, as if your risk factors were reduced as much as possible. The result is your "target" risk age or health score. It shows your potential benefit, in health terms, of improving your lifestyle-if you quit smoking, wear safety belts, take moderate exercise, etc.

Therefore, your health risk appraisal report includes your real age, your current risk age and your target risk age. Your current risk age tells you how healthy your lifestyle is right now, and your target risk age lets you know how much longer and healthier you can live with a few positive changes in your lifestyle.

PLEASE ANSWER QUESTIONS AS HONESTLY AND AS CORRECTLY AS YOU CAN. This will allow you to receive the most accurate assessment of your health.

The results of the Health Risk Appraisal are for you. No copy will be placed in your military or medical records. We ask that you give us your name so we can return your results and any recommendations for follow-up care to you. We also ask for your social security number so we can statistically track trends in health awareness over long periods of time. Statistical information may be collected from an armywide database which will contain your information, but your name and social security number will be covered and cannot be read. The rules of the Privacy Act apply to any information that you give in the Health Risk Appraisal.

IMPORTANT NOTE! The health risk appraisal is no substitute for a physical examination or check-up. It will not give you a diagnosis nor will it tell you how long you will actually live. However, the health risk appraisal will help you understand and recognize your risk factors.

Please use a No. 2 Pencil only to complete this survey. Make dark, black marks that fill the response boxes completely.
EXAMPLE: Correct ■ Incorrect ☑ ⊠ ◩

For MILITARY ONLY: Complete Questions 1-4.

1. What is your branch of service?

1. ☐ U.S. Army ☐ U.S. Marines ☐ U.S. Navy ☐ U.S. Coast Guard ☐ U.S. Air Force ☐ Other

2. What is your military status?

2. ☐ Regular Army ☐ USAR ☐ USAR/AGR ☐ ARNG ☐ ARNG/AGR ☐ Other

3. What is your current rank?

3.

ENLISTED		OFFICER		WARR. OFFIC.
☐ E-1	☐ E-6	☐ O-1	☐ O-6	☐ WO-1
☐ E-2	☐ E-7	☐ O-2	☐ O-7	☐ WO-2
☐ E-3	☐ E-8	☐ O-3	☐ O-8	☐ WO-3
☐ E-4	☐ E-9	☐ O-4	☐ O-9	☐ WO-4
☐ E-5		☐ O-5	☐ O-10	

4. What is your Unit Identification Code?
(Enter Specific Unit Identifier)

Print your Unit Identification Code in these blank boxes.

Then fill in the corresponding response box below each number/letter.

4.

UNIT CODE					
A B C D E F G H I J K L M N O P Q R S T U V W X Y Z 0 1 2 3 4 5 6 7 8 9					

PRIVACY ACT STATEMENT

AUTHORITY: 29 CFR Chapter XVII, Occupational Safety and Health Standards; 5 U.S.C., section 150; Executive Orders 11612 and 11807 authorize the c tion of this information.

PURPOSE: The primary use of this information is by the unit medical care providers to assure competent medical care. Additional disclosures of this information may be: To the Office of the Army Surgeon General in aggregated form to develop Army/Command fitness profiles; to Army medical researcher for the purpose of correlating health precursors to health problems or to commercial medical researchers for the same purpose. Where data from this system of records are provided to agencies external to the Army, Social Security Number and Name will be deleted.

ROUTINE USES: Information may be disclosed to departments and agencies of the Executive Branch in performance of their official duties relating to health risk analysis and cardiovascular screening.

DISCLOSURE: Furnishing the information required on this form is mandatory for all Department of the Army active duty and reserve component military personnel with the exception of name and social security number. We ask that you give your name so we ca eturn your results and any recommendations fc low-up care to you. We also ask for your social security number so we can statistically track trends in health awareness over long periods of time.

5. ☐ Spouse (husband or wife of active duty or Military Retiree)
☐ Retiree
☐ Son or daughter of Active Duty or Military Retiree
☐ DOD Employee
☐ Non-DOD Employee
☐ Other

5. For CIVILIANS ONLY: Complete Questions 5-6. Mark ALL categories applicable to you.

6. ☐ WG ☐ GS ☐ SES ☐ GM
☐ 1 ☐ 6 ☐ 11 ☐ 16
☐ 2 ☐ 7 ☐ 12 ☐ 17
☐ 3 ☐ 8 ☐ 13 ☐ 18
☐ 4 ☐ 9 ☐ 14
☐ 5 ☐ 10 ☐ 15

6. If you are a Civilian Government Employee, enter your category and current pay grade.

7. LAST NAME | FI

FOR ALL INDIVIDUALS

7. Your Name.

Print the first ten letters of your last name and your first initial in these blank boxes.

Then fill in the corresponding response box below each letter.

8. ☐ AD or RM
☐ Spouse of AD or RM
☐ 1st ☐ 2nd ☐ 3rd ☐ 4th ☐ 5th Child
☐ Not Applicable

8. ARE YOU: (Mark all applicable categories)
Active Duty of Retired Military
Spouse of Active Duty or Retired Military
1st, 2nd, 3rd, 4th, or 5th child of Active Duty or Retired Military
Not Applicable

9. YOUR SPONSOR'S SOCIAL SECURITY NUMBER OR YOUR SOCIAL SECURITY NUMBER

9.
- If ACTIVE DUTY or RETIRED military, enter your SSN
- If a FAMILY MEMBER OF active duty or retired, enter sponsors SSN
- For ALL OTHERS, enter your SSN

CARD 2

PAGE 2

10. This Health Risk Appraisal is being administered in the following situation:

10. ☐ In-Processing
☐ Periodic Physical Examination
☐ Pre-Physical Fitness Test
☐ Occupational Health Program
☐ Walk-In
☐ Other

11. Racial/Ethnic Background
Mark the most appropriate category.

11. ☐ American Indian or Alaska Native
☐ Asian/Oriental ☐ White, Hispanic
☐ Black, Hispanic ☐ White, Non-Hispanic
☐ Black Non-Hispanic ☐ Other
☐ Pacific Islander

12. Marital Status.
Mark the most appropriate category.

12. ☐ Married 1 ☐ Separated 4
☐ Never Married 2 ☐ Widowed 5
☐ Divorced 3 ☐ Other

13. Are you Male or Female?

13. ☐ Male ☐ Female

14. Your Age 15. Your Height 16. Your Weight

BEFORE you fill in the response boxes write age, height, and weight at the top of the columns.

14. AGE YEARS	15. HEIGHT FEET	INCHES	16. WEIGHT POUNDS
0 0	0	0 0	0 0 0
1 1	1	1 1	1 1 1
2 2	2	2 2	2 2 2
3 3	3	3 3	3 3 3
4 4	4	4 4	4 4 4
5 5	5	5 5	5 5 5
6 6	6	6 6	6 6 6
7 7	7	7 7	7 7 7
8 8	8	8 8	8 8 8
9 9	9	9 9	9 9 9

To determine Body Frame size, circle one wrist with the thumb and middle finger of the other hand

17. Your Body Frame Size:
- You are SMALL if the thumb and middle finger overlap.
- You are MEDIUM if the thumb and middle finger meet.
- You are LARGE if the thumb and middle finger do not meet.

17. ☐ Small
☐ Medium
☐ Large

18. How often do you do exercises that improve muscle strength, such as pushups, situps, weight lifting, a Nautilus/Universal workout, resistance training, etc...?

18. ☐ 3 or more times a week
☐ 1 or 2 times a week
☐ Rarely or never

19. How often do you do at least 20 minutes of non-stop aerobic activity (vigorous exercise that greatly increases your breathing and heart rate such as running, fast walking, biking, swimming, rowing, etc...)?

19. ☐ 3 or more times a week
☐ 1 or 2 times a week
☐ Rarely or never

20. How often do you eat high fiber foods such as whole grain breads, cereals, bran, raw fruit, or raw vegetables?

20. ☐ At every meal
☐ Daily
☐ 3-5 days a week
☐ Less than 3 days a week
☐ Rarely or never

21. How often do you eat foods high in saturated fats such as beef, hamburger, pork, sausage, butter, whole milk, cheese, etc...?

21. ☐ At every meal
☐ Daily
☐ 3-5 days a weeks
☐ Less than 3 days a week
☐ Rarely or never

22. Do you usually salt your food before tasting?

22. ☐ Yes ☐ No

23 a. CAR/TRK/VAN ,000 | 23 b. MOTORCYCLE ,000

23.a. In the next 12 months how many thousands of miles will you travel by car, truck or van?

23.b. In the next 12 months how many thousands of miles will you travel by motorcycle?

NOTE: U.S. average for cars is 10,000 miles

24. ☐ Walk ☐ Bike ☐ Motorcycle ☐ Sub/Compact Car ☐ Mid or Full Car ☐ Bus/Subway/Train ☐ Truck/Van ☐ Stay at Home

24. On a typical day how do you usually travel? (Mark only one)

25. 0 1 | 0 1 2 3 4 5 6 7 8 9 | 0 1 2 3 4 5 6 7 8 9

25. What percent of the time do you usually buckle your safety belt when driving or riding?

EXAMPLE: 50% — 0 ■ 1 | 0 1 2 3 4 ■ 6 7 8 9 | 0 ■ 2 3 4 5 6 7 8 9

26. ☐ Less than 5 MPH Over ☐ 6-10 MPH Over ☐ 11-15 MPH Over ☐ More than 15 MPH Over ☐ Don't Drive

26. On the average, how close to the speed limit do you usually drive?

27. NO. OF TIMES | 28. NO. OF DRINKS

27. How many times in the last month did you drive or ride when the driver had perhaps too much alcohol to drink?

28. How many drinks of alcoholic beverages do you have in a typical week?

NOTE:
1 Drink = 1 glass of wine = 1 can of beer = 1 shot of liquor

EXAMPLE: 2 DRINKS — 0 2

IF YOU DON'T DRINK SKIP TO QUESTION 35

29. ☐ Yes 1 ☐ No 2 — 29. Have you ever felt you should cut down on your drinking?

30. ☐ Yes ☐ No — 30. Have people ever annoyed you by criticizing your drinking?

31. ☐ Yes ☐ No — 31. Have you ever felt bad or guilty about your drinking?

32. ☐ Yes ☐ No — 32. Have you ever had a drink first thing in the morning to steady your nerves or get rid of a hangover (eye opener)?

33. ☐ Yes ☐ No — 33. Do your friends ever worry about your drinking?

34. ☐ Yes ☐ No — 34. Have you ever had a drinking problem?

35. ☐ Yes ☐ No — 35. Have you ever been told that you have diabetes (or sugar diabetes)?

36. ☐ Yes ☐ No — 36. Are you now taking medicine for high blood pressure?

37. ☐ Daily or almost daily ☐ 3 to 5 days a week ☐ Less than 3 days a week ☐ Rarely or never

37. How often do you eat two well-balanced meals per day?

38. ☐ Daily or almost daily ☐ 3 to 5 days a week ☐ Less than 3 days a week ☐ Rarely or never

38. How often do you eat foods high in salt or sodium such as cold cuts, bacon, canned soups, potato chips, etc...?

39. 1 ☐ ☐ ☐ ☐ — Not Satisfied / Somewhat Satisfied / Mostly Satisfied / Totally Satisfied / Not Applicable

39. I am satisfied with my present job assignment and unit.

40. ☐ Money ☐ Social Life ☐ Family ☐ Supervisor ☐ Job ☐ Health ☐ No Problem

40. What causes the biggest problem in your life?

41. In the last year, how many serious personal losses or difficult problems have you had to handle (example, promotion passover, divorce/separation, legal or disciplinary action, bankruptcy, death of someone close, serious illness/injury of a loved one, etc.)?
41. ☐ Several ☐ Few ☐ Some ☐ None

42. In general, how satisfied are you with your life (e.g., work situation, social activity, accomplishing what you set out to do)?
42. ☐ Not Satisfied ☐ Somewhat Satisfied ☐ Most Satisfied

43. How often are there people available that you can turn to for support in bad moments or illness?
43. ☐ Never ☐ Hardly Ever ☐ Sometimes

44. How many hours of sleep do you usually get at night?
44. ☐ 5 Hours or less ☐ 6-8 Hours ☐ 9 Hours or more

45. Have you seriously considered suicide within the last two years?
45. ☐ Yes ☐ Yes, within the last year ☐ Yes, within the last 2 months ☐ No

46. How often do you have any serious problems dealing with your husband or wife, friends or with your children?
46. ☐ Often ☐ Sometimes ☐ Seldom

47. How often did you experience a major pleasant change in the past year? (for example, promotion, marriage, birth, award, etc.)?
47. ☐ Often ☐ Sometimes ☐ Seldom

48. How often has life been so overwhelming in the last year that you seriously considered hurting yourself?
48. ☐ Often ☐ Sometimes ☐ Seldom

49. In the past year, how often have you experienced repeated or long periods of depression?
49. ☐ Often ☐ Sometimes ☐ Seldom

50. In the past year, how often have your worries interfered with your daily life?
50. ☐ Often ☐ Sometimes ☐ Seldom

51. How often are you able to find times to relax?
51. ☐ Often ☐ Sometimes ☐ Seldom

52. How often do you feel that your present work situation is putting you under too much stress?
52. ☐ Often ☐ Sometimes ☐ Seldom

TOBACCO USE HISTORY

53. How many cigars do you usually smoke per day?
53. 0 1 2 3 4 5 6 7 8 9

54. How many pipes of tobacco do you usually smoke per day?
54. 0 1 2 3 4 5 6 7 8 9

55. How many times per day do you usually use smokeless tobacco? (Chewing tobacco, snuff, pouches, etc.)
55. 0 1 2 3 4 5 6 7 8 9

EXAMPLE: 20 times

56. CIGARETTE SMOKING
How would you describe your cigarette smoking habits?
56. ☐ Never Smoked (SKIP TO QUESTION 58) ☐ Current Smoker ☐ Former Smoker

57. STILL SMOKE
a. How many cigarettes a day do you smoke?

USED TO SMOKE
b. How many years has it been since you smoked cigarettes fairly regularly?
c. What was the average number of cigarettes you smoked per day during the two years before you quit?

57. a. NUMBER b. YEARS c. AVG
0 1 2 3 4 5 6 7 8 9

58. About how long has it been since you had a rectal exam?
58. ☐ Less than 1 year ☐ 1 year ☐ 2 years ☐ 3 or more years ☐ Never

59. When was the last time you visited the dental clinic for a check-up?
59. ☐ Within the last year ☐ Between one and two years ago ☐ Over two years ago

WOMEN ONLY

60. 5 6 7 8 9 10 / 11 12 13 14 15 16 17 18 19 20 — **60. At what age did you have your first menstrual period?**

61. 0 No Children; 10 / 11 12 13 14 15 16 17 18 19 20 / 21 22 23 24 25 26 27 28 29 30 / 31 32 33 34 35 36 37 38 39 40 / 41 42 43 44 45 46 47 48 49 50 — **61. How old were you when your first child was born?**

62. ☐ Less than 1 year ☐ 1 year ☐ 2 years ☐ 3 or more years ☐ Never — **62. How long has it been since your last breast X-ray (Mammogram)?**

63. 0 1 2 3 4 5 6 7 8 9 10 — **63. How many women in your natural family (mother and sisters only) have had breast cancer?**

64. ☐ Yes ☐ No ☐ Don't know — **64. Have you had a hysterectomy operation?**

65. ☐ Less than 1 year ☐ 1 year ☐ 2 years ☐ 3 or more years ☐ Never — **65. How long has it been since you had a pap smear for cancer?**

66. ☐ Monthly ☐ Rarely/Never ☐ Every few months — **66. How often do you examine your breasts for lumps?**

67. ☐ Less than 1 year ☐ 1 year ☐ 2 years ☐ 3 or more years ☐ Never — **67. About how long has it been since you had your breasts examined by a physician or nurse?**

MEN ONLY

68. ☐ Less than 1 year ☐ 1 year ☐ 2 years ☐ 3 or more years ☐ Never — **68. About how long has it been since you had a prostate (rectal) exam?**

69. ☐ Monthly ☐ Rarely/Never ☐ Every few months — **69. How often do you do a testicular (sex organ) self exam?**

Questions 70 - 76 should be completed by MEDICAL PERSONNEL ONLY.

70. TOTAL CHOL — 71. HDL CHOL — 72. B.P.-SYSTOLIC (three digit columns each, 0–9)

70. Blood Lipids Total Cholesterol (mg/dl) **71. Blood Lipids HDL Cholesterol (mg/dl)** **72. Blood Pressure (Systolic)**

73. 12 HR. FAST — 74. CAS. NON-FAST — 75. B.P.-DIASTOLIC (three digit columns each, 0–9)

73. Blood Glucose 12 HR. Fasting (mg %) **74. Blood Glucose Casual Non-fasting (mg %)** **75. Blood Pressure (Diastolic)**

76. ☐ NL ☐ ABN w/LVH ☐ ABN w/o LVH ☐ UNKNOWN — **76. Most recent electrocardiogram results.**

X1. 0 1 2 3 4 5 6 7 8 9 10
X2. 0 1 2 3 4 5 6 7 8 9 10
X3. 0 1 2 3 4 5 6 7 8 9 10
X4. 0 1 2 3 4 5 6 7 8 9 10
X5. 0 1 2 3 4 5 6 7 8 9 10
X6. 0 1 2 3 4 5 6 7 8 9 10
X7. 0 1 2 3 4 5 6 7 8 9 10
X8. 0 1 2 3 4 5 6 7 8 9 10

APPENDIX 11

Studies 2 and 3

Data Form and Codes Used to Record Injuries and Illnesses

INJURY MEDICAL RECORDS REVIEW

Name:_____ Review Date_____

Lab ID #

Subject #

SSN #

Diagnosis_____

MO. YR. VISIT IC SD PART DISP TYPE DAYS LOST

Diagnosis_____

MO. YR. VISIT IC SD PART DISP DAYS

Diagnosis_____

MO. YR. VISIT IC SD PART DISP DAYS

Injury/Illness Codes

Visit
1=Initial injury
2=Recurring/chronic
3=Follow Up
96=NA
97=Other
98=Unknown

Injury/Illness Code
1=Stress Fx
2=Stress Reaxn
3=Tendonitis
4=Bursitis
5=Fascitis
6=Overuse injury
7=Traumatic injury
8=Pain
9=Strain
10=Sprain
11=Dislocation
12=Fracture
13=Blister
14=Abrasion/Laceration
15=Contusion
16=Heat Injury
17=Cold Injury
18=Ingrown Toenail
19=Numbness
20=Dehydration
96=NA (injury)
97=Unknown (injury)
98=Other (injury)
101=Viral
102=Bacterial
103=Mycoplasma
104=Fungal
105=Unknown infection
106=Inflammation
107=Non-Specific Rash
108=Immunization
109=Allergy
110=Degenerative
111=Arrythmia
112=Cardiovascular
113=Blood
114=Environmental
115=Bite
116=STD
196=NA (illness)
197=Unknown (illness)
198=Other (illness)
200=Pharmacological

Body Part
1=Head
2=Face
3=Neck
4=Chest
5=Abdomen
6=Upper Back
7=Shoulder
8=Upper Arm
9=Elbow
10=Lower Arm
11=Wrist
12=Hand
13=Finger
14=Lower Back
15=Pelvis
16=Hip
17=Thigh
18=Knee
19=Calf
20=Shin
21=Ankle
22=Foot
23=Toe
24=Genital(inj)
96=NA (injury)
97=Other (inj)
98=Unknown (inj)
101=Upper Resp
102=Lower Resp
103=Upper GI
104=Lower GI
105=Both GI
106=Urinary
107=Genitalia
108=STD
109=Upper Derm
110=Lower Derm
111=Both Derm
112=Heart
113=Circulatory
114=CNS
115=Eyes
116=Ears
117=Psych
118=Endocrine
196=NA (illness)
197=Other (ill)
198=Unk (illness)

APPENDIX 12

Studies 2 and 3

Physical Fitness Assessment

LINE 17

NAME	DATA	COLUMN	FORMAT	MISSING VALUE CODE
BOXNO	Subject number	1-5	00000	Blanks
LINE	Line number (17)	7-8	00	Blanks
STATUS	Status 1=student military 2=student military aviator 3=student military female 4=student International Fellow 5=student civilian 6=student civilian female 7=faculty/staff military 8=faculty/staff civilian 9=faculty/staff military aviator	21	0	Blanks
AGE	Age (years)	23-26	00.0	Blanks
SEX	Gender (1=male; 2=female)	35	0	Blanks
SERV	Service 1=Active Army 2=Active Navy 3=Active Air Force 4=Active Marine 5=Reserve Army 6=Reserve Navy 7=Reserve Air Force 8=Reserve Marines 9=Coast Guard 10=Faculty Civilian 11=Staff Civilian 12=Other Civilian	37-38	00	Blanks
RANK	Rank 1=2LT; 2=1LT; 3=CPT; 4=MAJ; 5=LTC; 6=COL; 7=BG; 8=MG; 11=Junior NCO; 12=Senior NCO; 13=Civilian.	40-41	00	Blanks
BRANCH	Speciality (corps, various codes)	43-44	00	Blanks

CODING FOR BRANCH

BRANCH:
01 = Adjutant General Corp
02 = Air Defence Artillery
03 = Armor
04 = Army Medical Dept.
05 = Army Medical Spec. Corp
06 = Army Nurse Corps
07 = Aviation
08 = Chaplains
09 = Chemical Corps
10 = Civil Affairs/Mil Government
11 = Corps of Engineers
12 = Dental Corps
13 = Field Artillery
14 = Finance Corps
15 = General Officers
16 = Infantry
17 = Judge Advocate General Corps
18 = Medical Corps
19 = Medical Service Corps
20 = Military Intelligence Branch
21 = Military Police Corps
22 = Ordinance Corps
23 = QuarterMaster Corps
24 = Retired Reserve
25 = Signal Corps
26 = Staff Specialist
27 = Transportation Corps
28 = Veterinary Corps
29 = Special Forces
30 = Not Applicable

LINE 18

NAME	DATA	COLUMN	FORMAT	MISSING VALUE CODE
BOXNO	Subject number	1-5	00000	Blanks
LINE	Line number (18)	7-8	00	Blanks
WT	Weight (kg)	15-19	000.0	0
HT	Height (cm)	21-25	000.0	0
BF	Body fat (%)	47-50	00.0	0
LBM	Fat free weight (kg)	52-55	00.0	0

LINE 19

NAME	DATA	COLUMN	FORMAT	MISSING VALUE CODE
BOXNO	Subject number	1-5	00000	Blanks
LINE	Line number (19)	7-8	00	Blanks
HRSPR	Heart rate sitting (b/min).	11-13	000	Blanks
SBPSPR	Systolic blood pressure sitting (mmHg).	14-16	000	Blanks
DBPSPR	Diastolic blood pressure sitting (mmHg).	17-19	000	Blanks
HRSUPR	Heart rate supine (b/min).	20-22	000	Blanks
SBPSUPR	Systolic blood pressure supine (mmHg).	23-25	000	Blanks
DBPSUPR	Diastolic blood pressure supine (mmHg).	26-28	000	Blanks
TMTPR	Treadmill time (min)	30-33	00.0	0
MVO2PR	VO2max (ml/kg/min)	35-38	00.0	0
MVEPR	VEmax (l/min)	40-44	000.0	0
MHRPR	HRmax (b/min)	46-48	000	Blanks
MSBPPR	SBPmax (mmHg)	50-52	000	Blanks
MDBPPR	DBP max (mmHg)	54-56	000	Blanks
HR3PR	Heart rate 3 min post exercise (b/min)	58-60	000	Blanks
SBP3PR	SBP 3 min post exercise (mmHg)	62-64	000	Blanks
DBP3PR	DBP 3 min post exercise (mmHg)	66-68	000	Blanks

LINE 20

NAME	DATA	COLUMN	FORMAT	MISSING VALUE CODE
BOXNO	Subject number	1-5	00000	Blanks
LINE	Line number (20)	6-7-8	00D	Blanks
SBPRPR	Resting SBP (mmHg)	19-21	000	Blanks
DBPRPR	Resting DBP (mmHg)	23-25	000	Blanks
LVHPR	Left ventricular hypertrophy (1=yes, 2=no)	27	0	Blanks
CIGPR	Cigarette smoking (1=YES; 2=NO; 3=FORMER SMOKER)	28	0	Blanks
CIGNSPR	Non Smoking Time (no. of months)	29-31	000	Blanks
CIGHISPR	Cigarettes per day (largest # while smoking)	33-35	000	Blanks
GLUPR	Glucose (mg/dl)	37-39	000	Blanks
CHOLPR	Cholesterol (mg/dl)	41-43	000	Blanks
TRIGPR	Triglycerides (mg/dl)	45-48	0000	Blanks
HDLPR	High density lipoproteins (mg/dl)	49-51	000	Blanks
FCHPR	Family cardiac history (1=negative; 2=positive before age 50; 3=positive after 50)	53	0	Blanks
FRIPR	Framingham Risk Index (% chance of cardiovascular disease in next 6 years)	55-59	00.00	Blanks
DRUGPR	Drugs (1=beta blocker; 2=diauretics; 3=vasodilators; 4=calcium channel blockers)	61-62	00	Blanks

LINE 23

NAME	DATA	COLUMN	FORMAT	MISSING VALUE CODE
BOXNO	Subject number	1-5	00000	Blanks
LINE	Line number (23)	7-8	00	Blanks
FLEXPR	Flexibility (ins)	10-14	000.0	0

LINE 24

NAME	DATA	COLUMN	FORMAT	MISSING VALUE CODE
BOXNO	Subject number	1-5	00000	Blanks
LINE	Line number (24)	7-8	00	Blanks
BP1RM	Bench press 1 RM (lbs)	10-12	000	Blanks
ACSMAE	American College of Sports Medicine Guidelines 1=exceeds; 2=meets; 3=below ACSM Endurance guidelines	20	0	Blanks
ACSMRT	American College of Sport Medicine Guidelines 1=exceeds; 2=meets; 3=below ACSM Resistance Training guidelines	38	0	Blanks
TE1RM	Triceps extension (1 RM) (lbs)	45-47	000	Blanks
KE1RM	Knee extension (1 RM) (lbs)	54-56	000	Blanks
KF1RM	Knee flexion (1 RM) (lbs)	60-62	000	Blanks

LINE 26

NAME	DATA	COLUMN	FORMAT	MISSING VALUE CODE
BOXNO	Subject number	1-5	00000	Blanks
LINE	Line number (26)	7-8	00	Blanks
RVPR	Residual volume (liters)	43-46	0.00	0

APPENDIX 13

Studies 2 and 3

Physical Activity and Health Questionnaire - Parts 1 and 2

PHYSICAL ACTIVITY AND HEALTH QUESTIONNAIRE

PART 1

In this questionnaire you will be asked about yourself and your lifestyle. This will include questions about how much exercise you do and any injuries you have had in the past. Read each question carefully and answer as accurately as possible.

I. GENERAL QUESTIONS

1. NAME: _____
LAST FIRST M

2. GENDER: ☐ MALE ☐ FEMALE

3. SSAN ___ __ ____

4. SUBJECT NO _____

5. AGE __

6. ETHNIC GROUP

	3. SSAN	4. SUBJECT NO	5. AGE
0	☐☐☐ ☐☐ ☐☐☐☐	☐☐☐☐☐☐	
1	☐☐☐ ☐☐ ☐☐☐☐	☐☐☐☐☐☐	☐☐
2	☐☐☐ ☐☐ ☐☐☐☐	☐☐☐☐☐☐	☐☐
3	☐☐☐ ☐☐ ☐☐☐☐	☐☐☐☐☐☐	☐☐
4	☐☐☐ ☐☐ ☐☐☐☐	☐☐☐☐☐☐	☐☐
5	☐☐☐ ☐☐ ☐☐☐☐	☐☐☐☐☐☐	☐☐
6	☐☐☐ ☐☐ ☐☐☐☐	☐☐☐☐☐☐	☐☐
7	☐☐☐ ☐☐ ☐☐☐☐	☐☐☐☐☐☐	☐☐
8	☐☐☐ ☐☐ ☐☐☐☐	☐☐☐☐☐☐	☐☐
9	☐☐☐ ☐☐ ☐☐☐☐	☐☐☐☐☐☐	☐☐

6. ETHNIC GROUP
☐ ASIAN
☐ BLACK
☐ HISPANIC
☐ WHITE
☐ OTHER

7. RANK: 2LT ☐ 1LT ☐ CPT ☐ MAJ ☐ LTC ☐ COL ☐ BG ☐ MG ☐ LG ☐ GEN ☐

8. TIME IN SERVICE: (YEARS)

0	1	2	3	4	5	6	7	8	9
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

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II. PHYSICAL ACTIVITY AND PHYSICAL FITNESS

1. PHYSICAL ACTIVITY

A. Compared to others of your age and sex, would you consider yourself to be:

VERY INACTIVE	SOMEWHAT INACTIVE	AVERAGE	ACTIVE	VERY ACTIVE
☐	☐	☐	☐	☐

B. How many <u>times per week</u> do you engage in any regular activity like jogging, bicycling, etc. long enough to work up a sweat?

None	1	2	3	4	5	6	7 or more
☐	☐	☐	☐	☐	☐	☐	☐

C. PAST PHYSICAL ACTIVITY: In general, about how many <u>hours per week</u> did you regularly participate in sports and other vigorous physical activities (excluding walking and time spent in school physical education classes)....

(1) during junior high school or high school years (ages 12 - 18 yrs)?

None	1	2	4	6	8	10	12	14	16 or more
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

(2) during college and early military assignments (ages 19 - 34 yrs)?

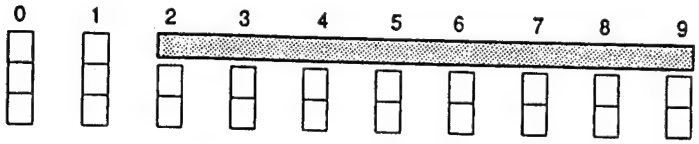
None	1	2	4	6	8	10	12	14	16 or more
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

(3) in the military more recently (ages 35 - 49 yrs)?

None	1	2	4	6	8	10	12	14	16 or more
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

D. WALKING

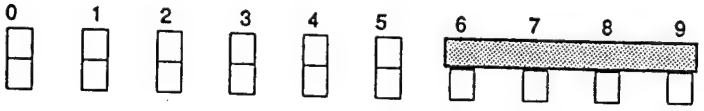
A. How many city blocks or their equivalent do you regularly walk each day? (Let 12 blocks = 1 mile).



B. What is your usual pace of walking?

- ☐ Casual or strolling (less than 2 MPH).
- ☐ Average or normal (2 to 3 MPH).
- ☐ Fairly brisk (3 to 4 MPH).
- ☐ Brisk or striding (4 MPH or faster).

C. How many flights of stairs do you climb up each day ? (let 1 flight = 10 steps).



2. PHYSICAL FITNESS

Compared to others of your age and sex, how would you rate your.....

	FAR BELOW AVERAGE	BELOW AVERAGE	AVERAGE	ABOVE AVERAGE	FAR ABOVE AVERAGE
A. ENDURANCE	☐	☐	☐	☐	☐
B. SPRINT SPEED	☐	☐	☐	☐	☐
C. STRENGTH	☐	☐	☐	☐	☐
D. FLEXIBILITY	☐	☐	☐	☐	☐

III. HEALTH AND PAST INJURIES AND ILLNESSES

1. LOST DUTY DAYS:

Have you ever suffered an injury or accident that resulted in your being on profile, limited duty or on quarters?

☐ NO

☐ YES If yes, list the one or two most recent ones and the years.

YEAR 80 81 82 83 84 85 86 87 88 89 90

INJURY _____

_____

DO NOT USE

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 96 97 98

2. SURGERY:

Have you ever had an injury or accident that required surgery to repair the damage?

☐ NO

☐ YES If yes, list the one or two most recent ones and the years.

YEAR 80 81 82 83 84 85 86 87 88 89 90

INJURY _____

_____

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 96 97 98

3. HOSPITALIZATION FOR INJURY:
Have you ever had an injury or accident that caused you to be in the hospital overnight?

☐ NO

☐ YES If yes, list the one or two most recent ones and the years.

YEAR 80 81 82 83 84 85 86 87 88 89 90

INJURY _____

4. HOSPITALIZATION FOR ILLNESS:
Have you ever had an illness that caused you to be in the hospital overnight?

☐ NO

☐ YES If yes, list the one or two most recent ones and the years.

YEAR 80 81 82 83 84 85 86 87 88 89 90

INJURY _____

DO NOT USE

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 96 97 98

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 96 97 98 200

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5. HEAT OR COLD INJURY:

Have you ever sufferred a heat or cold injury?

- ☐ NO
- ☐ YES, BOTH
- ☐ YES, HEAT
- ☐ YES, COLD

If yes, list the one or two most recent ones and the years.

	YEAR (80 81 82 83 84 85 86 87 88 89 90)	INJURY
HEAT		
COLD		

6. INJURIES IN VARIOUS PARTS OF THE BODY:

Have you ever injured any of the following body parts?

	FEET	LEGS	LOWER BACK	ARMS OR TRUNK
NO	☐	☐	☐	☐
YES	☐	☐	☐	☐

If yes, list the one or two most recent ones and the years.

	YEAR (80 81 82 83 84 85 86 87 88 89 90)	INJURY
FEET		
LEGS		
LOWER BACK		
ARMS TRUNK		

DO NOT USE

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 96 97 98

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IV. EXERCISE AND SPORTS IN THE LAST 2 MONTHS

1. EXERCISE IN THE LAST 2 MONTHS:

How often did you exercise or play sports in the last 2 months on an average basis?

- ☐ None in the last 2 months
- ☐ Less than once per week
- ☐ 1 time per week
- ☐ 2 times per week
- ☐ 3 times per week
- ☐ 4 times per week
- ☐ 5 times per week
- ☐ 6 times per week
- ☐ 7 or more

2. ENDURANCE TRAINING:

A. How many times did you do endurance exercise for 15 minutes or more in the last 2 months on an average basis?

- ☐ None in the last 2 months
- ☐ Less than once per week
- ☐ 1 time per week
- ☐ 2-3 times per week
- ☐ 4-5 times per week
- ☐ 5-6 times per week
- ☐ 7 or more

B. When you did endurance exercise in the last 2 months, how many minutes did you exercise on an average basis?

- ☐ Did not do endurance exercise
- ☐ Less than 10 minutes
- ☐ 10 - 15 minutes
- ☐ 15 - 30 minutes
- ☐ 30 -45 minutes
- ☐ 45 - 60 minutes
- ☐ 60 - 90 minutes
- ☐ 90 - 120 minutes
- ☐ 120 or more

3. STRENGTH TRAINING:

How many times did you do strength training for 15 minutes or more in the last 2 months on an average basis?

- ☐ None in the last 2 months
- ☐ Less than once per week
- ☐ 1 time per week
- ☐ 2 times per week
- ☐ 3 times per week
- ☐ 4 times per week
- ☐ 5 times per week
- ☐ 6 times per week
- ☐ 7 or more

4. STRETCHING:

Was stretching before or after exercise a regular part of your exercise program in the last 2 months?

- ☐ No, did not exercise in the last 2 months
- ☐ No, I exercised but did not stretch
- ☐ I stretched less than half the time
- ☐ I stretched more than half the time
- ☐ I always stretch when I exercise

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V. MISCELLANEOUS QUESTIONS

1. FEET:

How would you classify your feet?

- ☐ Flat
- ☐ High Arches
- ☐ Normal

2. KNEES:

How would you classify your knees?

- ☐ Knocked knees
- ☐ Bowed legged
- ☐ Normal

3. FOOT PROBLEMS:

Do you have problems with your feet that cause you to limit your daily activities sometimes?

- ☐ Yes
- ☐ No

4. BACK PAIN:

Do you have back pain that causes you to limit your daily activities sometimes?

- ☐ Yes
- ☐ No

5. SPRAINED ANKLES:

Have you ever had a sprained ankle that restricted what you could do?

- ☐ No
- ☐ Yes

If yes, what ankle(s) (right or left) and most recent year.

☐ RIGHT ANKLE

YEAR

70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90

☐ LEFT ANKLE

YEAR

70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90

10003

Form Number 75020-5-72

SURVEY NETWORK™

PART 2

PHYSICAL ACTIVITY AND HEALTH QUESTIONNAIRE

In this questionnaire you will answer questions about your physical activity during the academic year and any injuries and/or illnesses you suffered at Carlisle Barracks. Read each question carefully and answer as accurately as possible. If you need additional space use the back of the page. If you have questions call CPT(P) Knapik at (508)651-5134 or AV256-5134.

I. GENERAL QUESTIONS

1. NAME _____
last first mi

2. BOX NO. _____ 3. DATE _____
day mo yr

II. EXERCISE AND SPORTS DURING THE ACADEMIC YEAR

1. **GENERAL SPORTS AND EXERCISE:** Did you participate in any sports, exercise or vigorous recreational activity at least once during the academic year?

[ ] No

[ ] Yes. If yes, list the sports, exercise or recreational activity and other information below. Examine the list of sports, exercise and vigorous recreational activity (Appendix 1) to help your recall.

Sports/Exercise/ Activity	Number of Months of Participation	Average Days per Week During Months of Participation	Average Duration Each Time (min)	Was This Activity With Your Seminar Group?	
				Yes	No

2. STRETCHING

a. Was stretching before or after exercise a part of your exercise program during the academic year?

[ ] No, I did not exercise during the academic year
[ ] No, I exercised but did not stretch
[ ] I stretched less than half the time COMMENTS:
[ ] I stretched more than half the time
[ ] I always stretch when I exercise

b. When you stretched before or after exercise how many minutes did you stretch on an average basis?

[ ] Did not stretch during the academic year
[ ] Less than 1 minute
[ ] 1-5 minutes COMMENTS:
[ ] 6-10 minutes
[ ] 11-15 minutes
[ ] 16-30 minutes
[ ] 31 or more minutes

c. If you stretched during the academic year, which body part(s) did you stretch (for example: calves, back, thighs, etc.)?

List _____

_____

III. INJURIES AND ILLNESSES DURING THE ACADEMIC YEAR

1. SPORTS OR EXERCISE INJURY: During the academic year, did you injure yourself in any sport or exercise activity?

[ ] No
[ ] Yes. If yes, list the sports or exercises and injuries in the order of seriousness:

Sports/Exercise	Injury	Body Part (e.g. arm, neck, knee)	Side of Body (if applicable) Rt	Lt	No. days on Profile (if any)	Month Injury Occurred (e.g. Jan)
1.						
2.						
3.						
4.						

Comments _____

_____

2. LOST DUTY DAYS FOR INJURY OR ILLNESS (OTHER THAN SPORTS AND EXERCISE): During the academic year, did you suffer any injury, accident or illness (unrelated to sports or exercise) that resulted in your being on profile, limited duty or quarters?

[ ] No

[ ] Yes. If yes, list the injuries, accidents and/or illnesses in the order of seriousness:

Injury/Accident/Illness	Body Part (e.g. arm, neck, knee)	Side of Body (if applicable) Rt	Lt	No. of Days of Profile (if any)	Month Injury Occurred (e.g. Feb)
1.					
2.					
3.					
4.					

Comments _____

_____

3. SURGERY: During the academic year, did you suffer any injury, accident or illness that required surgery?

[ ] No

[ ] Yes. If yes, list the injuries, accidents and/or illnesses in the order of seriousness:

Injury/Accident/Illness	Body Part (e.g. arm, neck, knee)	Side of Body (if applicable) Rt	Lt	No. of Days of Profile (if any)	Month Injury Occurred (e.g. Mar)
1.					
2.					
3.					
4.					

Comments _____

_____

4. **HOSPITALIZATION:** During the academic year, did you suffer any injury, accident or illness that caused you to be in the hospital overnight?

[ ] No

[ ] Yes. If yes, list the injuries, accidents and/or illnesses in the order of seriousness:

Injury/Accident/Illness	Body Part (e.g. arm, neck, knee)	Side of Body (if applicable) Rt	Lt	No. days in Hospital	Month Injury Occurred (e.g. Jan)
1.					
2.					
3.					
4.					

Comments _____

_____

5. **BACK PROBLEMS:** Did you have a back problem that altered your daily activity during the academic year?

[ ] No

[ ] Yes. If yes, complete the following:

Type of Back Problem (e.g. Pain, Strain, etc.)	Number of Days of Altered Activity

6. KNEE PROBLEMS: Did you have a knee problem that altered your daily activity during the academic year?

[ ] No
[ ] Yes. If yes, complete the following:

Type of Knee Problem (e.g. Pain, Strain, etc.)	Number of Days of Altered Activity

APPENDIX 1
LIST OF SPORTS, EXERCISE AND RECREATIONAL ACTIVITIES*
(SEE SECTION II. Question 1)

CONDITIONING ACTIVITIES
- RUNNING/JOGGING
- WEIGHT LIFTING (RESISTANCE TRAINING)

WATER ACTIVITIES
- WATER SKIING
- SAILING
- CANOEING
- SWIMMING
- SCUBA DIVING
- SURFING
- ROWING

WINTER ACTIVITIES
- DOWNHILL SKIING
- CROSS COUNTRY SKIING
- ICE SKATING
- SLEDDING OR TOBOGGANING
- SNOWSHOEING

SPORT ACTIVITIES
- VOLLEYBALL
- BASKETBALL
- SOFTBALL
- RACQUETBALL
- TENNIS
- TABLE TENNIS
- BADMINTON
- PADDLEBALL
- SQUASH
- SOCCER
- GOLF
- FISHING
- HUNTING
- BOWLING
- POOL OR BILLIARDS

OTHER ACTIVITIES
- BICYCLING
- HORSEBACK RIDING
- MARTIAL ARTS
- HIKING
- BACKPACKING
- ROCK CLIMBING
- PARACHUTING

*Note: You are not limited to these activities. These are just to help your recall.

OCCUPATIONAL MEDICINE, USARIEM 1991
SPORTS, EXERCISE AND RECREATIONAL ACTIVITES CODING SHEET
FOR THE CARLISLE QUESTIONNAIRE DATA
COLLECTED IN APRIL - MAY 1991.

CODING	ACTIVITIES
01	AEROBIC EXERCISE
02	BACKPACKING
03	BADMINTON
04	BASKETBALL
05	BICYCLING
06	BOWLING
07	CANOEING
08	CROSS COUNTRY SKIING
09	DOWNHILL SKIING
10	FISHING
11	FLAG FOOTBALL
12	GOLF
13	HIKING
14	HORSEBACK RIDING
15	HUNTING
16	ICE SKATING
17	LACROSSE
18	MARTIAL ARTS
19	NORDIC TRACK
20	PADDLE BALL
21	PARACHUTING
22	POOL OR BILLIARDS
23	PUSH UPS
24	RACQUETBALL
25	ROCK CLIMBING
26	ROLLERBLADES
27	ROWING
28	RUNNING/JOGGING
29	SAILING
30	SCUBA DIVING
31	SIT-UPS
32	SLEDDING OR TOBOGGANING
33	SNOWSHOEING
34	SOCCER
35	SOFTBALL
36	SQUASH
37	SURFING
38	SWIMMING
39	TABLE TENNIS
40	TENNIS
41	VOLLEYBALL
42	WALKING
43	WATER SKIING
44	WEIGHT LIFTING (RESISTANCE TRAINING)
45	WOOD CHOPPING
46	HANDBALL
47	KICKBALL
48	PULL UPS
49	STAIRMASTER

Appendix 14-Odds Ratios for Musculoskeletal Disorders According to Cigarette Smoking Status Within Strata for Potential Confounders.

Potential Confounders	Never Smokers		Former Smokers		Current Smokers	
	Cases/n	OR	Cases/n	OR	Cases/n	OR
Age (yrs)						
38-42	10/38	1.0	5/20	0.93	0/2	0.70*
> 42-44	11/49	1.0	7/27	1.21	5/12	2.47
> 44	6/25	1.0	9/17	3.56	3/8	1.90
Body Mass Index (kg/m^2)						
≤ 24.5	3/26	1.0	5/16	3.49	2/6	3.83
> 24.5-25.9	10/33	1.0	4/14	0.92	2/4	2.30
> 25.9-27.3	5/27	1.0	6/14	3.30	2/6	2.20
> 27.3	9/26	1.0	6/20	0.81	2/6	0.94
Drinks per Week						
0-2	12/57	1.0	3/17	0.80	1/6	0.75
> 2-6	10/32	1.0	12/23	2.40	3/7	1.65
>6	5/23	1.0	6/24	1.20	4/9	2.88
Max Oxygen Uptake						
≤ 38.8	9/26	1.0	4/15	0.69	5/11	1.57
> 38.8-43.4	6/28	1.0	6/19	1.69	2/7	1.47
> 43.4	8/43	1.0	11/27	3.01	0/1	2.19*
Activity Level (Kcal/kg)						
≤ 862	9/36	1.0	3/16	0.69	6/8	9.0
>862-1502	8/34	1.0	6/21	1.30	0/3	0.54*
>1502	8/34	1.0	11/24	2.75	1/5	0.81

* 0.5 added to zero cells to calculate odds ratios.

Appendix 15-Odds Ratios for Musculoskeletal Disorders According to Tobacco Use, Within Strata for Potential Confounders.

Potential Confounders	Never Users		Former Users		Current Users	
	Cases/n	OR	Cases/n	OR	Cases/n	OR
Age (yrs)						
38-42	9/35	1.0	3/14	0.79	3/11	1.08
> 42-44	9/45	1.0	6/26	1.20	8/17	3.56
> 44	6/24	1.0	9/17	3.38	3.9	1.50
Body Mass Index (kg/m^2)						
≤ 24.5	3/24	1.0	5/16	3.18	2/8	2.33
> 24.5-25.9	8.31	1.0	3/12	0.96	5/8	4.79
> 25.9-27.3	5/26	1.0	6/13	3.60	2/8	1.40
> 27.3	8/23	1.0	4/16	0.63	5/13	1.17
Drinks per Week						
0-2	11/55	1.0	3/17	0.86	2/8	1.33
> 2-6	9/29	1.0	10/19	2.47	6/14	1.67
>6	4/20	1.0	5/21	1.25	6/15	2.67
Max Oxygen Uptake						
≤ 38.8	9/23	1.0	4/15	0.57	5/14	0.86
> 38.8-43.4	6/27	1.0	5/15	1.75	3/12	1.17
> 43.4	6/40	1.0	9/24	3.40	4/7	7.56
Activity Level (Kcal/kg)						
≤ 862	8/31	1.0	3/15	0.72	7/14	2.88
>862-1502	8/34	1.0	6/20	1.39	0/4	0.41*
>1502	6/31	1.0	8/19	3.03	6/13	3.57

* 0.5 added to zero cells to calculate odds ratios.

Appendix 16-Odds Ratios for Lower Extremity Musculoskeletal Disorders According to Cigarette Smoking Status Within Strata for Potential Confounders.

Potential Confounders	Never Smokers		Former Smokers		Current Smokers	
	Cases/n	OR	Cases/n	OR	Cases/n	OR
Age (yrs)						
38-42	5/38	1.0	3/20	1.17	0/2	1.65*
> 42-44	2/49	1.0	3/27	2.94	4/12	11.75
> 44	2/25	1.0	6/17	6.27	2/8	3.83
Body Mass Index (kg/m^2)						
≤ 24.5	0/26	1.0	2/16	7.43*	1/6	10.4*
> 24.5-25.9	3/33	1.0	3/14	2.73	1/4	3.33
> 25.9-27.3	3/27	1.0	2/14	1.33	2/6	4.00
> 27.3	3/26	1.0	5/20	2.56	2/6	3.83
Drinks per Week						
0-2	3/57	1.0	3/17	3.86	1/6	3.60
> 2-6	3/32	1.0	7/23	4.23	3/7	7.25
>6	3/23	1.0	2/24	0.61	2/9	1.91
Max Oxygen Uptake						
≤ 38.8	4/26	1.0	2/15	0.85	3/11	2.06
> 38.8-43.4	1/28	1.0	4/19	7.20	2/7	10.08
> 43.4	2/43	1.0	6/27	5.86	0/1	10.25*
Activity Level (Kcal/kg)						
≤ 862	4/44	1.0	1/19	0.56	5/14	5.56
>862-1502	2/34	1.0	4/21	3.77	0/3	2.67
>1502	3/34	1.0	7/24	4.26	1/5	2.58

* 0.5 added to zero cells to calculate odds ratios.

Appendix 17-Odds Ratios for Musculoskeletal Disorders According to Tobacco Use Status Within Strata for Potential Confounders.

Potential Confounders	Never Users		Former Users		Current Users	
	Cases/n	OR	Cases/n	OR	Cases/n	OR
Age (yrs)						
38-42	5/35	1.0	1/14	0.46	2/11	1.33
> 42-44	0/45	1.0	2/26	7.50*	7/17	63.00*
> 44	2/24	1.0	6/17	6.00	2/9	3.14
Body Mass Index (kg/m^2)						
≤ 24.5	0/24	1.0	2/16	6.86*	1/8	6.86*
> 24.5-25.9	2/31	1.0	2/12	2.90	3/8	8.70
> 25.9-27.3	3/26	1.0	2/13	1.39	2/5	2.56
> 27.3	2/23	1.0	3/16	2.42	5/13	6.56
Drinks per Week						
0-2	3/55	1.0	3/17	3.71	1/8	2.48
> 2-6	2/29	1.0	5/19	4.82	6/14	10.13
>6	2/20	1.0	1/21	0.45	4/15	3.27
Max Oxygen Uptake						
≤ 38.8	4/23	1.0	2/15	0.73	3/14	1.30
> 38.8-43.4	1/27	1.0	3/15	6.50	3/12	8.67
> 43.4	1/40	1.0	4/24	7.80	3/7	29.3
Activity Level (Kcal/kg)						
≤ 862	4/39	1.0	1/18	0.52	5/20	2.92
>862-1502	2.34	1.0	4/20	4.00	0/4	2.00
>1502	1/31	1.0	4/19	8.00	6/13	25.70

* 0.5 added to zero cells to calculate odds ratios.

CURRICULUM VITAE

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A. EDUCATION

Boston University, School of Public Health
Boston, Massachusetts
D.Sc., Epidemiology, January 1996
Dissertation: Musculoskeletal Disorders Related to Cigarette Smoking and Tobacco Use

Boston University, Sargent College
Boston, Massachusetts
M.S., Physical Therapy, September 1980
Thesis: Effects of Postural Drainage Positions and Percussion on the Blood Pressure of Normal Human Subjects

University of Connecticut, College of Allied Health
Storrs, Connecticut
B.S. (magna cum laude), Physical Therapy, May 1974

B. ACADEMIC EXPERIENCE

University of Massachusetts Lowell
College of Health Professions
Department of Physical Therapy
Assistant Professor, 1989 - present
Instructor, 1987 - 1989

Boston University
Sargent College of Allied Health Professions
Department of Physical Therapy
Clinical Assistant Professor, 1980 - 1987
Teaching Assistant, 1979 - 1980

Boston University
School of Public Health
Department of Epidemiology and Biostatistics
Teaching Assistant, 1990

C. PROFESSIONAL EXPERIENCE

Boston University Faculty Practice
Boston, Massachusetts

Physical Therapist, 1986-1987

Mount Auburn Hospital
Department of Physical Therapy
Cambridge, Massachusetts
Physical Therapist, 1976-1979, June-July 1982

New England Memorial Hospital
Department of Physical Therapy
Stoneham, Massachusetts
Physical Therapist, 1974-1976

D. PROFESSIONAL ACTIVITIES

1. Professional Licensure

Licensed Physical Therapist
Massachusetts L #2748
Connecticut L #1727

2. Professional Honors and Awards

Dorothy Briggs Memorial Scientific Inquiry Award, from American Physical Therapy Association for the article "Effects of Selected Bronchial Drainage Positions and Percussion on Blood Pressure of Healthy Human Subjects", co-authored by D.J. White and R.H. Mawdsley. Physical Therapy 63:325-330, 1983. Award received June, 1984.

E. RESEARCH

1. Grants and Contracts

Traineeship Grant
Boston University School of Public Health
Academic Year 1993-94, $150.

Graduate Traineeship Grant
Foundation for Physical Therapy
Academic year 1987-1988, $7500.

"Effects of Bronchial Drainage and Adjunct Physical Therapy on Cardiovascular Function Following Open Heart Surgery." New Faculty Research Support, Boston University, July 1981, $1500.

2. Academic and Professional Publications

Articles in Refereed Journals

White, D.J., Mawdsley, R.H.: "Effects on Selected Bronchial Drainage Positions and Percussion on Blood Pressure of Normal Human Subjects." Physical Therapy 63:325-330, 1983.

Goldberg, L.K., White, D.J., Pandolf, K.B.: "Cardiovascular and Perceptual REsponses to Isometric Exercise." Archives of Physical Medicine and Rehabilitation 63:211-216, 1982.

Books

Norkin, C.C., White, D.J.: Measurement of Joint Motion: A Guide to Goniometry, ed. 2. Philadelphia, F.A. Davis Co., 1995.

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Published Abstracts of Conference Proceedings:

White, D.J., Brawner, J.B., Fielding, D.E., LeJacq-Smith, C: "Current Practices of Physical Therapist in Obstetric Care. Physical Therapy 68:961, 1988.

Kirschner, T.C., Andres, P., White, D.J., Coryell, J.: "Reliability of Finger and Foot Tap Tests on Normal and Amyotrophic Lateral Sclerosis Subjects." Physical Therapy 67:768, 1987.

White, D.J., Kraus, S., Mahan, C., Swartz, K.L.: " Reliability of Three Clinical Methods of Measuring Lateral Flexion in the Thoracolumbar Spine." Physical Therapy 67:759, 1987.

White, D.J., Darrock, S.A., Short, M.H., Hopke, M.A.: "Reliability of Three Methods of Measuring Cervical Motion." Physical Therapy 66:771, 1986.

Hamilton, S.L., Miller, P.W., Phillips, K.: " Cardiovascular Function in Lateral Trendelenburg Positions." Physical Therapy 64:733, 1984.

White, D.J., Breen, J.C.: "Effects of Forearm Position on Measurement of Glenohumeral Rotation." Physical Therapy 64:739, 1984.

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